AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

PUBLISHED MONTHLY AT NO. 47 CEDAR STREET, NEW YORK.

M. N. FORNEY, ... Editor and Proprietor.
FRANK J. FRENCH, ... Business Manager.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid............$3 00
Subscription, per annum, Foreign Countries........... 3 50
Single Copies.. 25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

The paper may be obtained and subscriptions for it sent to the following agencies:
Chicago, News Stand, Grand Pacific Hotel.
London, England, Sampson Low, Marston & Co., Limited, St. Dunstan's House, Fetter Lane, E. C.
Berlin, Germany, W. H. Kühl, 73 Jäger St.

NEW YORK, AUGUST, 1894.

EDITORIAL NOTES.

THE Secretary of the Master Car-Builders' Association has issued his call for the letter ballot on the new standards that have been offered for adoption. The one which affects the largest number outside the railroad circles—in fact, the only one which does so—is that relating to the standard sizes of catalogues, circulars and specifications. It is needless to recapitulate the troubles experienced in every office in the care of catalogues, for they are very familiar to all, so the adoption of the standard may be urged on the ground of being a public benefit; and when this has been done, the fact should be extensively advertised in order that manufacturers and others may shape new catalogues in accordance with the sizes recommended.

ANOTHER proposed standard that will save a deal of misunderstanding is the one defining the terms used with reference to wheels and gauges. It might be impossible for any twelve men to agree on the most desirable point at which to locate the gauge line of car wheels; but that is no reason why all hands should not agree to adopt some specific point. Any point from the bottom of the throat to the back of the flange is better than the indefiniteness that now exists. If any one is dissatisfied with the selections made, it is no reason why he should not vote for the adoption, for in private calculations he can act as he chooses, and only when in communication with outsiders will he be obliged to speak the common tongue.

IN our column for Notes and News we chronicle two cases of record breaking that cannot fail to be of interest to those interested in naval affairs. The British Navy is now in possession of the fastest vessel in the world. The *Daring*, built by Messrs. Thornycroft & Co., has eclipsed all rivals by developing the tremendous speed of 29.3 knots for a single spurt over a measured mile. This is at the rate of nearly 34 miles an hour, or nearly up to the average express speeds between New York and Chicago a few years ago, and ahead of any speed yet developed by a boat in America. Not less remarkable and interesting is the record-breaking that has been accomplished by the *Minneapolis*, a sister ship to the *Columbia*—herself a record-breaker. Thus, England has a torpedo-boat chaser that can overhaul anything as yet afloat, and the United States has a cruiser capable of overhauling any sea-going passenger or freight steamer. The *Minneapolis* has netted her builders a fortune in the premium which she has won, and the question is being raised as to whether it would not be advisable to discard the payment of such sums as are now paid when the contract speeds are exceeded. A few years since it may be that American designers were unable to predict with precision the performance of their vessels, but surely such a state of affairs belongs to the past. Then it is doubted by many whether premiums should be paid for a speed that can never be attained while the vessel is in service, and which was attained under conditions that will never arise again.

AFTER THE BATTLE.

SOME one has said that "human experience, like the sternlights of a ship at sea, illumines only the path which we have passed over," and it might also be added that on the great ocean of life the course in which others have sailed vanishes like the phosphorescent wake of a vessel, and is thus only a momentary guide to those who follow. Experience in the past seems to have taught mankind only to a very limited extent how to avoid mistakes, and it will probably not be a much better pilot in the future. Still, as civilization has advanced, the rocks and shoals and currents have been encountered and have been marked, and some of those who are wise learn how to avoid them.

The great Pullman strike has darkened the land, has apparently failed of its purpose, or, as the newspapers announce, has "collapsed." It has caused a lamentable loss of life, great destruction of property, and enormous expense. Its direct cost is now estimated at from five to eight millions of dollars, and besides that the business of the whole country was temporarily checked and thousands of people were subjected to incalculable inconvenience and hardship. There is nothing new in all this. It is but a repetition, in a somewhat larger scale, of what has occurred over and over again. The questions which have arisen are the same, and the methods adopted for forcing a determination of them are those with which a hundred years or more of experience has made us familiar.

I the effect upon the stricken, there seems to be a noticeable analogy between a strike and a pestilence. Probably the great proportion of people who are attacked with disease regard their affliction as an exceptional visitation, and out of the regular order of events, or as something which, like an evil spirit, has invaded the system and requires to be exorcised. The experienced physician, however, has a "clear recognition of disease as being, equally with life, a process governed by what we should now call natural laws, which can be known by observation, and which indicate the spontaneous and normal direction of recovery, by following which alone can the physician succeed." Strikes are a disease of the social organism, and as ineradicable, probably, as measles or catarrh are in the human race.

Of late years, the phrase "crushing out strikes" is not heard as often as it was ten or twenty or more years ago. In those days, when a strike occurred, the image which many people seemed to have in their minds was that of the picture of St. George and the dragon, in which the employer

was St. George and the strike was the great beast, which was being trampled under foot and about to be decapitated. Somehow or other, though, this creature seemed to be a kind of a phœnix, which, if slain either by fire or sword, rose again to trouble its slayer. The attitude of mind of the people referred to was somewhat like that of those self-righteous individuals who resolved " that the earth is the possession of the saints," and who further resolved that " we are the saints.". Human nature is unfortunately so constituted that in any contest we always think that we are St. George and the other party is the dragon. At present the parties in labor contests have improved upon ancient mythology, and in the imagery of modern science " labor" pictures its employer as an octopus; and some employers appear to regard those who work for them as a kind of human microbes which infest the body politic.

To a student and observer of " the labor question," as it is called, both of these views are obviously false. The fact is, disputes between working men and their employers are as natural a result of the clashing of opposing or divergent interests as disease is of the activity and environment of the human body. Life is largely made up of disputes and adjustments of our relative interests. In our daily intercourse with our fellow-men, we adopt all sorts of means to settle or bring such altercations to a satisfactory issue, so that we may be agreed if differences arise.

Experience has evolved several methods which mankind employ to adjust their disputes. There is, first, what may be called the *barbarous* method of fighting it out, which is as old as the world and which still survives, and of which Shakespeare said:

> "——shall your swords and lances *arbitrate*
> The swelling difference of your settled hate?"

Then there is the *rational* way, very generally adopted in civilized communities and in all relations of life—that of *compromise*, or, as the dictionary expresses it, " a reciprocal abatement of extreme demands and rights, resulting in an agreement." Of this method Burke said, " All government, indeed every human benefit and enjoyment, every virtue and every prudent act is founded on it." If this fails, rational people resort to the *impartial* method of *arbitration*, which is defined as " the hearing and determination of a cause between parties in controversy by a person or persons chosen by the parties." Trial by jury, now a universal method of deciding disputes in civilized countries, is an evolution of the underlying idea of arbitration, which is, that two people or parties having a dispute involving personal interests will be prejudiced thereby, and therefore incapable or disqualified to judge impartially. This is a simple recognition of a trait of human nature which experience has revealed to all of us. Consequently, under such circumstances, a third party, who has no such interests and prejudices, and whose judgment would therefore not be likely to be unbalanced, is called in, and the differences are submitted to him or them with the agreement that both disputants shall then submit to the decision of the arbitrator. The law provides that the reference of certain kinds of disputes to the arbitration of a jury shall be compulsory, and supplies means for enforcing the decisions which are then made.

In arbitration there is a recognition of the general principle, confirmed by universal human experience, that in disputes personal interests are liable to blind the eyes and pervert the sense of justice of those concerned, and therefore that the determination of the matter at issue should be made by a person whose judgment is not thus perverted.

It ought also be pointed out that *arbitration* does not mean *compromise*, as many persons seem to think. Judging from the newspaper reports, neither Mr. Pullman nor his chief lieutenant, Mr. Wickes, distinguished clearly the difference in the significance of the two words. A *compromise* is " a reciprocal abatement of extreme demands and rights," while *arbitration* is the hearing and determination of a cause between parties by a third person or persons chosen by the parties. Obviously, then, there might be arbitration either with or without compromise. If one or more arbitrators had been called in before the late strike occurred, and the question in dispute had been submitted to him or them, the decision probably would have been that Mr. Pullman was altogether right and the men were in the wrong; which might have prevented the strike, with all its lamentable consequences.

Both Mr. Pullman and his representatives said they "had nothing to arbitrate," which, in substance, was saying, " we are so sure we are right that we can't be wrong," or an assumption of infallibility, which is a prerogative claimed by the Pope alone, and which is conceded to him by only a fraction of mankind. If it had been said that " we will make no compromise, and don't choose to submit any question to arbitration," they would have been saying what, it is true, they have a perfect legal right to say; and it would have expressed what they have the same right to do; but was it the most expedient course to pursue? If the position of the Pullman Company was so absolutely right and just as it was assumed to be, what reason is there for thinking that an intelligent, impartial and righteous arbitrator would have decided otherwise?

The alternatives which were presented may be represented typographically thus:

I.

ARBITRATION.

With a fair prospect of an amicable settlement of the dispute, but with the risk that no arbitrators could be chosen who would be sufficiently disinterested and wise enough to make a decision which would be just to the Pullman Company.

II.

"NOTHING TO ARBITRATE."

With the chance of a strike, which might and did cost millions of dollars, great suffering and much loss of life.

On the doctrine of business chances, which alternative was it the wisest to accept? There are possibly mathematicians who could calculate the value of the probability that no man or men could have been found to act as arbitrators, whose wisdom and sense of justice would, under the circumstances, have been adequate to making an equitable decision. That risk may be represented by n, and the chances of a strike which were incurred by the decision that there was " nothing to arbitrate" by M, and readers can assign values to the symbols. It is true that the Pullman or any other company has a perfect legal right, under such circumstances, to take either alternative; but in the present portentous aspect of this, the most important question of modern times, what would have been the wisest course to pursue?

Employers and men, it is thought, might with advantage study the meaning of the word *opportunist*, which is now encountered so often, and the policy which it personifies. The dictionary says that in politics it means one who " believes in regulating political action in accordance with circumstances and not by dogmatic principles; in general, one who makes the best of circumstances." Is it making the best of circumstances in an irreconcilable dispute, in which we are exposed to great risks, to take the position that we will not be guided by the decisions of any one else, no matter how just or wise or righteous those decisions may be?

There is a doctrine which is now floating about very generally, that when a person is absolutely certain in his own mind that he is right, that then there is nothing to arbitrate. It is safe to say that in all disputes which cannot be settled by conciliative methods there is always something which could be arbitrated—that is, there is always, in such cases, some subject or matter of disagreement which may be referred to a competent third party for decision. Probably nine men out of ten who come into our courts of justice with their disputes are sure that they have right and justice on their side, and if asked, would say,

as Mr. Pullman did, that they have nothing to arbitrate; and yet, in such cases, the law compels arbitration by judge and jury; which method, even if it does not always result in the administration of strict justice, at least has the merit, which other kinds of arbitration have, of ending contention, and is thus better than the barbarous method of reaching a decision by fighting it out.

Probably, though, the chief obstacle in the way of the adoption of arbitration to settle labor disputes is that which was very clearly stated by the editor of the New York *Sun*, who said:

"It is natural that neither side should wish to take the chances of arbitration in a struggle in which it thinks itself the stronger. Finally, arbitration can hardly help being a curtailment of rights which one party has, or thinks he has. Why should he submit to such a curtailment?"

This objection to arbitration comes from the employed as well as from the employers, and the former often make the mistake of striking first and asking for arbitration afterward, or, as the writer in the *Sun* aptly observed, "The labor agitators never want to resort to it until the hopelessness of a strike has been demonstrated. After they have caused many acts of violence and much destruction of property, they profess to be the friends of peace and arbitration."

Both parties often go into such contests with the hope and expectation that they can, by skillful management of their cause, gain an undue advantage for their side, or, in the vernacular of the shop, can "beat" the other side.

In contrast to this spirit, some experience in the settlement of a dispute some years ago on the New York Central Railroad, when Mr. William H. Vanderbilt was still at the head of that company, may be cited. At that time there was some dissatisfaction among the engineers of the road, and they had a "grievance" which had been in a state of incubation for some time, until the men were worked up to the striking point. Mr. Buchanan, who was then, as he is now, the Superintendent of Motive Power of that line, reported to Mr. Vanderbilt that he thought the men were about to strike. "What do you think we had better do?" Mr. Vanderbilt asked. Mr. Buchanan's recommendation was that Mr. Vanderbilt should meet a committee representing the men and hear their complaints and consider their cause of discontent. Mr. Vanderbilt said, "That is a good idea," and directed that the committee should be invited to meet him in his office the next day. When they arrived he treated them with consideration, told them how important their services were to the company, and had them state the cause of their discontent, which he listened to patiently. He then pointed out wherein their demands were unreasonable, and explained why he could not grant all they asked; but made such concessions as were just, and the interview wound up by formulating a proposition for mutual agreement, to be submitted by the committee to the men they represented. It was so submitted, and was satisfactory to and accepted by the men, and there was no strike, no declaration of war, no violation of law, destruction of life or property, and none of the untold evils which so often attend strikes. This, it is said, was the first committee of this kind which Mr. Vanderbilt ever "received." There is no record that this interview detracted in any way from the honor or dignity of the high position which his wealth and office gave him, or that he lost any of the influence or authority which it was his duty to exercise over the men employed on the road. On the contrary, there is every reason to believe that such negotiations, when conducted with the intention and purpose of dealing fairly, increase the esteem in which those who take part in them mutually hold each other. Mr. Buchanan, in the case cited, suggested, and Mr. Vanderbilt adopted the rational method of settling the dispute instead of the barbarous one. Now, it is quite conceivable that, in such an interview of conciliation, the two parties might not agree, as they happily did in the instance referred to. What then? must there be a declaration of war and another sacrifice of more millions of property? The impartial method of arbitration is still open. That is, if, after a full discussion, the two parties should fail to agree, they might or should assume that one or both of them are prejudiced by their own interests, which is the reason for calling in a disinterested party.

An instance of successful conciliation and arbitration was described recently in a letter of a correspondent of the London *Times* of June 19th, in which the action of the miners and the owners of mines in Northumberland and Durham, where the long and disastrous strike occurred not long ago, is described. This action seems to be of so much importance as an example of the methods which are employed in England at present to avoid and prevent strikes, that we reprint the report of it to which reference has been made. The correspondent of the *Times* said:

While the Scottish miners, who recently allied themselves with the National Federation, are preparing for a strike, the miners of Northumberland and Durham, who form the National Union, and are outside of the Federation, are in the enjoyment of undisturbed industrial peace. Their good fortune is due to the fact that they are at present engaged along with the owners in the formation of boards of conciliation. The disastrous conflict of 1892 awakened both employers and employed to a keener sense of the value of industrial peace. This lesson of experience was promptly and zealously pressed home by, among others, the Bishop of Durham, through whose intervention the wasteful dispute was at last brought to a close. After a brief interval Dr. Westcott began to hold private and informal conferences with leading employers of labor and the more prominent representatives of the miners in Northumberland, Durham and Cleveland, with the view of commending to them the "more excellent way" of conciliation, and of ascertaining their feeling on the subject. He was so much encouraged by these conferences that he was induced to convene a representative meeting of employers and employed to discuss openly the questions which had already been privately investigated and deliberated upon. The result of this meeting was, briefly, a hearty and unanimous acceptance of the principle of conciliation. Both employers and employed declared their desire to have the days of lockouts and of strikes ended. They agreed in the opinion that, whichever side nominally won, both sides were always heavy losers by the stoppage of work—that not only was machinery depreciated and capital left unemployed on the part of the owners, while wages were sacrificed on the part of the workmen to an extent far greater than could ever be recouped by a slight advance in the rate of pay, but that trade was diverted to the foreign competitor, that markets once lost were not easily recovered, and that the industrial supremacy of England was recklessly imperilled. Both parties frankly admitted that their interests were indissolubly united, and that these mutual interests could only be fairly and fully promoted by means of a policy of peace.

No formal resolution binding those who attended the public conference to any definite course was adopted. The proceedings, however, gave most encouraging promise of the adoption of a friendly understanding; and with as little delay as possible, yet without any tendency to undue haste, both parties proceeded to endeavor to form the desired board of conciliation. When the negotiations were in progress the coal owners of Northumberland gave a signal proof of their loyalty to the great and noble object of class conciliation, so eloquently and so disinterestedly commended by Dr. Westcott. The state of trade called upon them to ask their workmen to acquiesce in a slight reduction of wages, and they convinced the leaders of the miners that a reduction was justified by the lowered market prices. Nevertheless, the workmen, by a majority of votes, declined to acquiesce in the proposed reduction. In ordinary circumstances the owners would then have proceeded to issue their notices. In the interest of the board of conciliation then being formed, they, however, wisely and magnanimously forbore. They said they would delay their demand until the board was formed, and if the state of trade then seemed to call for a reduction they would submit their claim to the new body or court representing both employers and employed. Since then the Northumberland miners have officially intimated their acceptance of the constitution of the board framed by the representatives of both bodies, and the court of conciliation is now practically, though not yet formally, established. The rules provide that the board is to consist of 15 representatives from each side, with an independent

chairman. This chairman is to be elected annually by the members, and if they fail to agree, the chairman, for the time being, of the Northumberland County Council is to have the power, after conferring with the board, to nominate a gentleman for the office. The board is to have power to determine from time to time the county rate of wages. The chairman is to preside at all the ordinary meetings, and, in default of agreement on any question by the representatives of the owners and the workmen, he is to give the deciding vote, which is to be final and binding. The board is to continue until either party gives a month's notice of withdrawal, but neither side can withdraw before December 31, 1895.

The constitution of the Durham board has not yet been published, but the negotiations are making satisfactory progress, and it may be assumed that the same lines as those adopted in Northumberland will be followed. Meanwhile the movement in prices caused by the threatened strike in Scotland has changed the aspect of affairs, and in all probability nothing will be heard for some time to come of any proposal for a reduction of wages.

Such action as this, contrasted with the scenes of violence which occurred in Chicago and elsewhere, give much color of plausibility to the assertion of Mr. Stead, recently published in the *Contemporary Review*, that:

In industrial matters our American kinsfolk are where we were forty or fifty years ago, when rattening was the first word of an outlawed unionism and murder the ultimate argument against the blackleg. What Sheffield was in the palmy days of Broadhead and Crookes, before the Royal Commission was appointed which revealed the secrets of a unionism resting upon the foundation of assassination—preached as a virtue and practiced as a necessity—so Pittsburgh is to-day, and when we say Pittsburgh we say Chicago, Denver, or any other great industrial center. Our difficulties are bad enough, but they are as moonlight is to sunlight, as water is to wine compared with the industrial feuds which rage on the other side of the Atlantic.

This statement, which accords with the reports of many recent observers in America, is borne out by a dismal catalogue of violence on both sides, neither "hesitating to shoot," and the public doing nothing but keeping the ring. The Church is powerless and arbitration voted useless.

The great mischief in America is the absence of trust, the rooted disbelief in the honesty and good faith of anybody. Rightly or wrongly, American workmen seem to be convinced —I have heard picked leaders of American labor assert it again and again—that no award, no agreement is ever respected by their employers a day longer than it suits their interests to keep it. Bad faith on the part of the employers is balanced by murder and outrage on the part of the employed, while the Church, which should be the conscience of the community, is seared as with a hot iron by a conventional indifferentism to the affairs of this world.

That the fault is not alone on one side, and that there is some good ground for Mr. Stead's assertion, is indicated by the following extract from a sermon preached in New York since the first part of this article was written:

"I have often acted as an informal arbiter in settling disputes," the preacher said, "and I want to say that in the majority of cases I have found the unreasonable oppressor to be, not the employer, but the demagogue—the lazy scoundrel who, too miserably lazy to work, but with a plausible tongue in his head, found it more to his liking to run labor unions and draw a good salary from the hard earnings of his victims. It is he who, without regard to the conditions of trade, fosters in the bosom of the laboring man discontent and hatred of his employer."

That there is much truth in this view is also conceded. But it is not true that *all* the leaders of the working men, in their combinations for the protection of what they conceive to be their rights and their interests, are "demagogues," or "scoundrels," or "lazy." To be a leader of men in the defense of their just rights and interests is an honorable and a beneficent position for a man to occupy if he does it wisely and judiciously. It is true that the leaders of the men have not always been wise or judicious; that the chief characteristic of some of them seems to be an insatiable love of notoriety, but that is not confined to such leaders alone. Men like Mr. Debs may be guilty of unspeakable acts of folly, and may for that reason go into obscurity, but nevertheless trade unions will not be eradicated. Over and over again it has been announced that such unions have been broken up, but nearly always they have been reorganized stronger than they were before.

The newspapers have been pouring the vials of their wrath on the head of Debs, and probably little more will be heard of him. He and many of his friends and admirers have by this time learned that when they array themselves against the execution of the laws of the country, that the ultimate result is not doubtful; and that if the decision must be made, most of us will shoulder our muskets and will use them, if need be, in defense of law and order, no matter who is hurt. But while he may go into obscurity, trade unions are not and cannot be eradicated. The American Railway Union may be disintegrated, but the interests which it represented will be reorganized in some other form and probably by other people, and the same disputes will come up again and continue to come up. If the officers and representatives of the new associations are men of good sense and concerned most about the true interests of the members, and employers are disposed to deal fairly with them, conciliation and arbitration on a peaceful and rational basis will be possible; but if the men are represented by pot-house blatherskites, as they so often are, and if employers do not believe in nor practice the doctrine of fair play in their dealings with their men, and renew their attempts to crush out trade unions, then the barbarous methods will again be resorted to in settling disputes, which are sure to arise in the future as they have in the past. In this, as in the administration of nearly all other human affairs, the character of the administrators is the most important element.

It therefore seems of the utmost importance to employers, as well as to the men, that the officers of trade unions should be intelligent and fair-minded men. So long as a policy of repression is practiced toward trade unions, the best of the working men will be deterred from holding office in them. A hundred years of experience has shown as clearly as anything can be shown that trade unions, in a free country, cannot be "crushed out." The idea so fondly entertained by some that they can be exterminated is the blindest of folly. We will have trade unions of some kind as inevitably as we will have political caucuses, theaters and breweries. Whether these will be good or bad, whether the action of the first will be for the public good, the amusements of the second improving or degrading, and the product of the last wholesome or poisonous depends upon the people who control and conduct those "institutions." Any one of them may be the source of intolerable evil, or be a benefit to the community. It is so with a trade union. It would appear to be the part of wisdom for employers as well as working men to do all that is possible to secure their efficient organization, so that the men could be fairly represented, and the best of them should occupy the places of authority and influence, in which they have the power of doing so much harm or so much good.

What has been accomplished in England in the direction of amicable settlement of labor disputes is described as follows in a recent history.*

"In the business expansion of 1873-74," the historians say, "the employers, for the most part, abandoned their objection to recognize the unions, and even conceded, after repeated refusals, the principle or the regulation of industry by joint boards of conciliation or impartial umpires chosen from outside the trade. From 1867-75 innumerable boards of conciliation and arbitration were established, at which representatives of the masters met representatives of the trade unions on equal terms. In fact, it must have been difficult for the workmen at this period to realize with what stubborn obstinacy the employers between 1850-70 had resisted any kind of intervention in what they had then regarded as essentially a matter of private concern. When the Amalgamated Society of Engineers

* "The History of Trade Unionism." By Sidney and Beatrice Webb. London and New York: Longmans, Green & Co.

offered, in 1851, to refer the then pending dispute to arbitration, the master engineers simply ignored the proposal. The select committees of the House of Commons in 1856 and 1860 found the workmen's witnesses strongly in favor of arbitration, but the employers skeptical as to its possibility. Nor did the establishment of Mr. Mundella's Hosiery Board, at Nottingham, in 1860, and Sir Rupert Kettle's joint committees in the Wolverhampton building trades in 1864, succeed in converting the employers elsewhere. But between 1869-75 opinion among the captains of industry, to the great satisfaction of the trade, union leaders, gradually veered round. 'Twenty-five years ago,' said Alexander Macdonald, in 1875, 'when we proposed the adoption of the principle of arbitration we were then laughed to scorn by the employing interests. But no movement has ever spread so rapidly or taken a deeper root than that which we then set on foot. Look at the glorious state of things in England and Wales. In Northumberland the men now meet with their employers around the common board. . . . In Durhamshire a Board of Arbitration and Conciliation has also been formed; and 75,000 men repose with perfect confidence on the decisions of the Board. There are 40,000 men in Yorkshire in the same position.' "

Shall we in this country adopt methods which make for peace, or are we to have a perpetual declaration of industrial war?

"SUPPLEMENTARY OBSERVATIONS" OF THE ROYAL COMMISSION ON LABOR.

A Royal Commission has recently presented a final report to the British Parliament on the general subject of labor. Appended to the report were some supplementary "Observations" on the law relating to trade unions and employers' associations, which, it is said, were drawn up by the chairman, and were signed by him and several of the Commission. These "Observations," it is thought, will have very great interest in this country at the present time, when so much is being said about compulsory arbitration. The difficulties which are in the way of enforcing any such compulsion are very fully explained, and suggestions are made with reference to legislation on the subject, which are as applicable to the condition of things existing here as they are to those prevailing on the other side of the Atlantic. The greater part of these "Observations" are therefore reprinted. In them the Commission say:

"While agreeing with the report, so far as it extends, which we have signed together with the majority of our colleagues, we desire to call attention to some proposals discussed by the Commission, but with regard to which there proved to be no such general agreement as would justify their inclusion in the body of the report. It has been stated, in paragraph 153 of the report, that at present 'Collective agreements are, as a matter of fact, frequently made between great bodies of organized workmen and employers, which bodies have no legal personality and cannot sue or be sued for damages occasioned by the breach of such agreements by sections of their members. There is collective action without legal collective responsibility. While this state of things lasts it does not appear that such collective agreements can be, as between such bodies, otherwise than morally binding upon them.' We think that this state of things might be beneficially altered by some amendments of the existing law. In the following observations it must be borne in mind that when trade unions or trade associations are spoken of associations of employers as well as of workmen are included, and that if, in any particular instance, it appears to be suggested that special privileges should be conferred, or responsibilities imposed upon one class of such associations, it will probably be found that corresponding privileges or liabilities will attach to the other.

* * * * * * * * * *

"We think that the extension of liberty to workmen or employers to acquire fuller legal personality than that which they at present possess is desirable in order the better to secure the observance, at least for fixed periods, of the collective agreements which are now made between them in so many cases. The associations which might avail themselves of the liberty might, in some cases, be trade unions or employers' associations, and in other cases bodies of workmen employed in a few establishments, or even a body employed in a single establishment, according to the circumstances of each industry. We do not maintain that the scheme would be applicable to the circumstances of all, or even, at present, of the larger part of the industries of this country. We find, however, from the evidence, that a considerable and very important part of British industry is conducted under collective agreements made in the most formal way between highly organized trade associations, and that the substitution of agreements between associations for agreements between individual employers and individual workmen is a growing practice, and one which is intimately connected with the mode and scale upon which modern industry is at present carried on.

"It seems to us to be clear, from the evidence of both employers and employed, that the advantages of this system greatly outweigh the disadvantages. This may not have been so evident at the date when the Trade Union Act of 1871 was passed, but we think that it has now been sufficiently proved by experience that the agreements are, on the whole, in accordance with the public interest and with the circumstances of modern industry. If this is the case, then it seems to follow that further legislation is desirable to bring the law into harmony with the present state of facts and public opinion. We think that such an extension of liberty, if conceded (and in so far as it was acted upon), would not only result in the better observance for definite periods of agreement with regard to wage rates, hours of labor, apprenticeship rules, demarcation of work, profit sharing, and joint insurance schemes and other matters, but would also afford a better basis for arbitration in industrial disputes than any which has yet been suggested To enable trade associations to enter into collective, legally binding agreements, with the consequence that in case of breach of contract they would be liable to be sued for damages payable out of their collective funds, it would not be sufficient to repeal subsection 4 of section 4 of the Act of 1871. Even if that legislative incapacity were taken away, the trade associations would be prevented by their want of legal personality from entering into such agreements, or suing or being sued, except with regard to the management of their funds and real estate. It would be necessary that they should acquire by some process of registration a corporate character sufficient for these purposes. We are anxious to make it clear that we propose nothing of a compulsory character, but that we merely desire that trade associations should have the liberty, if they desire it, of acquiring a larger legal personality and corporate character than that which they possess at present. The further powers of incorporation would not be made a condition of the existing registration, but would be offered as powers to be obtained by registration under a new Act. The motive which would, it might be hoped, influence trade associations so to register would be the desire to acquire power to enter into agreements of a more solid and binding kind than heretofore. This might be sufficient in the case of an increasing number of the trade associations.

"With regard to the collective agreements, there should probably be some statutory condition attaching to them; for instance—(1) that every agreement should specify a period for which it was intended to hold good, and a period for notice of amendment or renewal; (2) that every agreement should be registered in central and local public offices, and should be open to inspection by the public; (3) that copies of every agreement should be kept open to inspection in factories and workshops which it affected. We think that the contracting association should be responsible for observance of the collective agreement by all its members so long as they remained its members, and that every member of an association should during membership be held to be under a contract with the association for observance of the collective agreement. The effect of this would be to give to those entering into contracts with an association the right to sue it for damages in case of breach of contract by it, or any of its members, and to give an association the right to recover damages from those of its members who infringed the collective agreement. For the more convenient enforcement of the latter right some power of deciding disputes between a society and its members similar to that conferred on friendly societies by section 22 of the Friendly Societies Act, 1875, might, perhaps, be extended to trade associations. Assuming the reform which we suggest to have taken place, we are aware that some litigation might arise before it was settled what collective agreements were or were not *ultra vires*, or 'in restraint of trade,' as the latter doctrine is now understood, or would be understood, by the courts of law. We think, however, we are justified in anticipating that judicial discussion of these matters would lead to reasonable solutions of the problems which might arise in each case, and to the gradual evolution of the best general principles.

"Apart from the question of collective agreements, it may, we think, be desirable to enable trade associations to take legal action in certain cases to secure the rights of their members, and at the same time to make them responsible and legally liable for acts done by persons when acting as their

agents. Reference has been made in paragraph 108 of the report to the injury which conduct not amounting to legal intimidation may inflict upon employers or non-unionist workmen, and it has been pointed out that such persons are not prohibited from bringing civil actions to recover damages on account of such wrongs. But at present no one can be sued except the individuals who commit such wrongs, against whom adequate damages cannot always be recovered, and there appears to be no reason why trade associations should not be liable to be sued for civil wrongs charged against their officials or other persons when acting as their agents. On the other hand, it might be equally expedient to confer upon registered trade associations power to take legal proceedings on behalf of their members—for instance, under the Employers' Liability or Truck Acts, or on other matters affecting trade relations.

"The Commission have had carefully to consider the question whether the State should attempt to do more than as proposed by Mr. Mundella's Bill—promote the formation of voluntary institutions of conciliation and arbitration. It appears from the evidence that there is in many quarters a desire, sometimes on the part of workmen, sometimes on that of employers, and in some cases felt by both, that the State should do something to replace strikes and lock-outs by a more peaceable and rational way of settling trade disputes. There does not seem to be any very clear idea as to the precise manner in which this end should be accomplished, but the general notion appears to be either that the State should establish tribunals of its own, with powers like those of ordinary law courts, or that it should invest with similar powers voluntarily formed industrial tribunals. To examine this question it is desirable, in the first place, to point out what the State cannot do according to the ordinary principles accepted in this country. It seems to be obvious that the State cannot compel either individuals or bodies of men to enter into agreements, and that the State cannot compel employers to give employment or workmen to do work upon terms which they do not respectively accept. Inasmuch as strikes and lock-outs are, in practice, the assertion of these essential liberties on the part of the employers and workmen, it is clear that the State cannot prohibit acts of this kind and compel the parties to resort to tribunals of any sort instead. It was suggested in the evidence that strikes and lock-outs should be illegal and punishable in cases where arbitration had not first been resorted to. But it seems, for the reasons just given, that it is impossible to make strikes or lock-outs illegal and punishable in any case, leaving out of consideration such exceptional cases as those of the Army or Navy or certain cases especially provided for by legislation where a sudden strike in breach of contract may involve actual danger to the public. Generally speaking, it may be laid down that the State cannot compel parties to submit to arbitration matters upon which they have a perfect right to take their own line, and it cannot compel either employers or workmen to carry out, by way of specific performance, an award as to wages or other terms of service. For these reasons the Royal Commission on Trade Unions of 1867 appears to have decided rightly (while warmly advocating the extension of voluntary institutions) that no 'system of compulsory arbitration' is practicable. The question, however, arises whether it is possible to devise any means short of compulsory arbitration by which the object so widely desired—that arbitration should replace strikes and lock-outs—might be more fully attained than it is at present. It seems that although the most formidable obstacles to resort to arbitration are probably those indicated in paragraphs 140 and 141 of the report, a further obstacle may frequently be found in the uncertainty which exists as to the observance of an award when given. If an arbitrator can only pronounce a decision which may or may not be followed according to the good will of the parties the procedure is to some extent discredited. Although, as a rule, arbitration awards may be loyally accepted, and the exceptions may be very few, yet the possibility of such an exception occurring may make employers or workmen less willing to resort to a troublesome and elaborate process like formal arbitration. It has been shown that it is impossible to compel the observance of any award in these matters. It remains to be considered whether any better guarantee or motive for such observance can be obtained to supplement and strengthen the moral force which already exists. To have arbitration in the strict sense of the word there must be two or more parties capable of entering into a legal contract to submit present or future questions to arbitration, and there must be such submission. Then, before the ordinary principle of law damages can be recovered from any party who refuses to go to arbitration, or declines to act on the award when made. As things now stand large bodies of workmen or employers cannot, as such bodies, enter into legal contracts of submission to arbitration for want of legal personality, and, for the same reason, damages cannot be recovered from them, as such bodies, for refusal to go to arbitration after agreeing to do so, or for refusal to accept the result of awards.

"If, however, the suggestions which we have made were adopted, and it were put within the power of such bodies to acquire legal personality sufficient to enable them to enter into collective agreements with the legal sanction of collective liability in damages for breach of such agreements, this difficulty would be so far solved. If, under such circumstances, a body had agreed to submit future disputes on one or more subjects to arbitration and subsequently refused to do so, and resorted to a strike or lock-out, it might be sued for damages, and the prospect of this, although it could not, indeed, prevent, would render less likely resort to such measures. If a strike or lock-out did take place, although it is true that any damages which could be recovered would probably not, except in the case of a small or partial conflict, be sufficient compensation, yet an action at law would render more visible the breach of contract, and serve to guide public opinion.

"The same observations will apply to the breach of an award made upon a submission under collective agreement. There would in both cases be the gain of a judgment publicly pronounced by a competent authority, and attended and emphasized by tangible results. For instance, an employer might insist on a reduction of wages contrary to a collective agreement or to an arbitration award founded upon a collective agreement. Then, instead of striking, the workmen might continue to work at the reduced wages, and through their association sue the employer or his association for damages to the amount of the loss. Or, on the other hand, workmen might insist on a rise of wages contrary to the collective agreement of the award. Then the employer, instead of locking-out or discharging the men, might give the increase under protest and sue their association for damages. The damages being recoverable from the collective funds of the association it would not be necessary to proceed against any individual workman. Or, again, supposing that a collective agreement were in existence between an association of employers and an association of workmen, providing that no change in rates of wages should take place without the sanction of a board of arbitration, then either side refusing to submit the question for arbitration, or to abide by the results, would be liable to be sued for damages. The judgment would be pronounced by a competent authority, would be made publicly, have tangible result, and thus greatly help to form public opinion.

"It has already been pointed out that the absence of any positive guarantee for the observance of awards may deter in many cases both employers and men from resorting in practice to arbitration, although they may in theory prefer it to strikes and lock-outs. It might be anticipated that if by the method of collective agreements a more concrete guarantee were given to arbitration it would be more frequently resorted to by those who have a *bonâ fide* preference for it over more violent modes of settling differences. It must further be observed that if trade associations were able as bodies with legal personality to refer present or future questions to arbitration they could by such agreements, under the ordinary law embodied in the Arbitration Act, 1889, either constitute or indicate their own tribunals or arbitrators and clothe them with all necessary powers of procedure and enable them to make awards which could if broken be made grounds of action for damages.

"Thus, in these cases, the problem of how to give powers of procedure to voluntarily formed boards of arbitration and a legal sanction to their awards would be solved by the operation of the ordinary law as to agreements made between parties capable of contracting. Inasmuch as such tribunals would in each case be constituted or indicated and armed with powers by the effect of the formal agreement of the parties interested, they would, it might be expected, be well regarded by them, while the fact that associations and not individuals were primarily responsible for the observance of the awards might remove some of the difficulties which have hitherto attended attempts to give a legal sanction to arbitration awards in industrial matters. These observations apply both to agreements for referring general questions and to those for referring minor questions to arbitration. Supposing, for instance, a case in which two associations of employers and workmen, capable under the supposed law of entering into collective contracts, had agreed to have (1) a wages board with provision for arbitration to settle changes in the rate of wages and other general questions, and (2) a joint committee with an independent chairman to decide minor questions arising with regard to existing agreements or customs, and had further agreed that all questions should be referred by them

and their members to these boards respectively. Then in either case the effect of the agreement would be to render liable to damages the association which, or the members of which, did not respect the arrangements, but resorted to strikes or lock-outs."

THE DISCUSSIONS AT THE CONVENTIONS.

Editor American Engineer and Railroad Journal:

Your notes on the Master Car-Builders' and Master Mechanics' conventions are well put together and to the point. Each suggestion you make would certainly improve matters.

There are still further suggestions to offer. The Master Mechanics certainly were not in session long enough to get through the business in a satisfactory manner. On Monday there was very little done practically; even the first report was not gotten through with. Why? Too much time taken up with other matters. We intended to open up at 9.30 A.M. By the time we got back to the hall it was after 11 o'clock. About 1 o'clock we had to stop our business, owing to the thunder-storm, as we were not able to hear the speakers.

Now, right here we lost so much time that we were not able to make it up the other two days.

On Tuesday we had to stop at noon hour to take up compound experiences. Here was another point lost of one hour which could (under the circumstances) have been used to better advantage. This was evident by the number of members leaving the hall when this discussion was opened.

On Wednesday it was a 'rush to get through and done, as it were, but still we had to resurrect the compound in the noon hour, thus losing another hour that could have been used to better advantage.

In reviewing the matter there was really very little time for discussion. The short time we were in session on Monday was occupied with the election of Auditing Committee, electing associate members, and voting on honorary members, and quite a parley of the "gaseous." Then reading of reports on Tuesday, which were very lengthy, took up so much time that very little was or could be done in the way of discussion.

Wednesday, with a lengthy report, resolutions, elections, etc., less was done. Now, it is all very well to find fault, but can we remedy it in the three days? The only remedy I see is:

First, let us open the meeting at 8 A.M. We are all at our business before that hour, and why not when we are in convention?

Second, hold two sessions on the first day if necessary.

Third, let every member speak so that *he knows* he can be heard by all. This will get the members more interested in the discussion. I sat in a good central location in the last convention, but could hear very few of the remarks made by those who were talking.

Fourth, now that the reports are to be sent to the members before leaving their homes, cannot the reading of reports be dispensed with? Could not the committee start the ball rolling by their individual remarks instead of reading the reports? This would save much time, as some of the reports are very lengthy. The members could read, mark, learn, and inwardly digest the reports before going to the convention. The reports were all very systematically prepared, and, through the nature of them, very lengthy, and if we could dispense with the reading, considerable time can be saved which would allow further discussion.

By following the above suggestions, coupled with a determination on the part of the speakers to be heard by all the members (and not get alongside the President and speak so that *he* is the only one he cares to hear him), more interest would be taken and less of the gag rules of closing the discussion which you complain of.

One Who Favors More Discussion.

NEW PUBLICATIONS.

Public Works and Mines, and the Traditions and Superstitions of all Countries. By Paul Sebillot. J. Rothschild, 13 Rue des Saints Pères, Paris. 623 pp., $5\frac{1}{2} \times 8\frac{3}{4}$ in.

The book opens with an exposition of the peculiar rites and ceremonies with which the ancients, and, for that matter, some people of modern times, presided over the constructions of roads. The author devotes himself to the various superstitions of travelers, both civilized and savage, concluding with the divinations and proverbs of all countries relatively to roads. This plan is followed in all of the monographs which compose the book. The author deals successively with highways, bridges, railways, dikes, canals, locks, aqueducts, lighthouses, mines and costumes. The monograph in regard to bridges is the longest in the book—probably because in this department, with the exception of lighthouses, materials are most abundant. This is probably due, as the author suggests, to the difficulties which meet the engineer in the construction of bridges, which is far more difficult than that of roads.

The Greeks and Romans—especially the latter—had a true worship for rivers, and their first care was to sacrifice to the divinities which presided over them in order to insure their favor, or at least their neutrality, so that the college of pontiffs at Rome occupied the position of priest and engineer; and it has only been in modern times that bridge builders have lost their sacred character.

The legends and stories which surround the building of bridges in the Middle Ages, in which the constructor made a league with the devil, and the old and oft-repeated story that the devil stipulated for the first living being that passed over the bridge, and that he was cheated by the substitution of animals for men, is met with on every hand.

Attention is especially directed to the important *rôle* which bridges played in the life of the cities of the Middle Ages, and of the many civil and religious ceremonies which were inaugurated at their opening, and the laying of their foundations. One of the most interesting chapters is that relating to railways, which has been compiled by the aid of very widely scattered documents, and which have been for the most part unedited. It is difficult for us to realize at present the great amount of superstition which surrounded the early establishment of railways, unless we are willing to consider that the peasantry of Europe regarded them in the early thirties in the same way that the Chinese do to-day. For example, on page 485 there is a prayer with which the Bishop of Orleans, M. Fayet, blessed the inauguration of the first great French railway—that from Paris to Orleans, on May 2, 1843—and it was specially recommended that all Christian followers should recite this prayer and meditate upon it when confiding themselves to the cars which carried them.

In the second part the monograph on mines and miners occupies about 200 pages. The belief that mines originated, for the most part, in something supernatural, and the singular ideas which were held in regard to them, are carefully developed. Their discovery was attributed to mysterious circumstances, and to the intervention of divinities or supernatural agencies. The timid imagination of miners peopled this dark world with strange apparitions, which almost always were of a mysterious and terrible nature. Their *rôle* is habitually that of a wicked demon provoking turmoils, kindling terrible fires, amusing themselves with terrible noise in mockery of the workmen, while the latter, in order to free themselves from the awe with which they were surrounded, had recourse to ceremonies which were for the most part purely superstitious. The costumes of miners are described in the last chapters.

The book is very fully illustrated, many of the engravings being borrowed from ancient works which treated upon the subjects handled, and the 430 illustrations of the volume form one of the most interesting features of the work. The concluding pages are occupied by a list of principal works which were consulted. It is necessary to read this varied detailed analytical table, which appears at the end of the volume, to appreciate the number of different subjects which have been consulted in the compilation of this work, which is, we believe, the first one published that takes this peculiar view of public works.

La Machine Locomotive. By Edouard Sauvage. Baudry & Co., Paris. 327 pp., $5 \times 7\frac{1}{2}$ in.

The author states, in his introduction, that the book is written in order to give locomotive engineers facility of access to a description of the locomotive engine and its method of operation. In the description of the parts and their method of operation, the author has certainly succeeded in making himself very clear; at the same time he has not attempted to cover up and slide over the difficulties which necessarily present themselves to the examination of certain portions of the engine, and he warns his reader that if any passage proves to be too difficult to grasp at the first reading, that he should not be discouraged, but study the passage carefully, and then return to it after reading other portions of the work. The book is divided into nine chapters, the first of which deals with generalities such as the origin of the power engine, the forces which it exerts, the temperature of steam, the pressure of steam, the methods of

combustion, the weight and traction which the engine can exert, the hours of labor, etc.

In Chapter II he takes up the matter of the boiler, handles it very carefully and thoroughly, and in a language that is exceedingly simple. The mechanism, frames, different types of locomotives, the tenders, methods of stopping, which include the various systems of brakes in use on the French railways and instructions for handling an engine, and the work which should be done at terminal stations, are successively dealt with, and in a manner so clear that it is difficult to understand why the author should have taken the precaution to advise his readers in his introduction that some passages would be difficult to understand, and it would be well to revert to them afterward. Necessarily, the author deals with the strictly French type of locomotive, as he is writing for men engaged in French railway service; but locomotive service is becoming cosmopolitan to such an extent that his instructions and comments regarding the methods of doing locomotive work, and the weak and strong parts of the engine, are equally applicable to American engines.

Mr. Sauvage has been for many years connected with the locomotive departments of two of the largest railway departments of France, the Northern and the Eastern line, and being in constant touch with the men on the road, and with the designing and construction of the engines, his qualifications for writing such a book are far above those of the average mechanical engineer. The book is very fully and completely illustrated, and what will undoubtedly add to its popularity is the fact that it is wonderfully free from mathematics. There is hardly a formula in the whole book, and nothing that requires any knowledge above that capable of handling the simplest arithmetical problems. Unfortunately for English readers, the book is in French; but it certainly seems that a translation would be an acceptable addition to the literature of English readers.

The Steam Engine and Other Heat Engines. By J. A. Ewing, Professor of Mechanism and Applied Mechanics in the University of Cambridge. Macmillan & Co., New York. 400 pp., 9 × 5¾ in.

Considering what a grand subject it is, it is surprising that there are so few good books on the steam engine. Probably there is no question which an editor of an engineering paper is called on to answer oftener than the inquiry, "Which is the best book on this subject?" and it is never asked without perplexing the editor. The book before us will not lessen, but rather increase, the difficulty of answering such inquiries.

In his preface the author says that some years ago he "undertook to prepare an article on the Steam Engine and other Heat Engines for the *Encyclopædia Britannica*, and it then seemed that the subject might be appropriately treated by following the general lines which had been found suitable in lecturing to students of engineering. The article was accordingly written on these lines, but necessarily in a very condensed form." His book, he tells us, is an expansion of that article, or, rather, is based on it, but with additions and changes which virtually make it a new work. It is very doubtful whether the "general lines which have been found suitable in lecturing to students" are often a good basis for a treatise on any subject. At any rate, probably readers will bear out the assertion that most books with lecture notes for their basis are not usually satisfactory treatises. Books, though, are like people; we must accept them as they are, with their characteristics, whatever they may be, and not what they might be.

The titles of the chapters of the book before us are The Early History of the Steam Engine; Elementary Theory of Heat Engines, Properties of Steam and Elementary Theory of the Steam Engine; Further Points in the Theory of Heat Engines; Actual Behavior of Steam in the Cylinder; the Testing of Steam Engines; Compound Expansion; Valves and Valve Gears; Governing; the Work on the Crank Shaft; the Production of Steam Boilers; Forms of the Steam Engine; Air, Gas and Oil Engines.

About half of the book is devoted to the theory of the steam engine and the other half to descriptions of its organs and their functions. In looking through its pages, one is disposed to say of it that what is "new in it is not true, and what is true is not new." The first part of the criticism, though, has little or no application, as there is not much that is new. The contents consist largely of fragmentary theories and statements of facts relating to the subjects discussed, which are collected together into chapters, and are often undigested, incomplete, and generally unsatisfactory.

The mechanical work—that is, the printing, paper and binding—are all excellent; and it has a good index, for which merits let the author and publisher be praised.

The Encyclopædia of Foundry and Dictionary of Foundry Terms used in the Practice of Molding. *Together with a Description of the Tools, Mechanical Appliances, Materials and Methods Employed to Produce Castings in all the Useful Metals and their Alloys, Including Brass, Bronze, Steel, Bell, Iron and Type Founding; with many Original Mixtures of Recognized Value in the Mechanic Arts. Also Aluminum, Plating, Gilding, Silvering, Dipping, Lacquering, Staining, Bronzing, Tinning, Galvanizing, Britannia Ware, German Silver, Nickel, Soldering, Brazing, Ores, Smelting, Refining, Assaying, etc.* By Simpson Bolland, Practical Molder and Manager of Foundries. New York: John Wiley & Sons. 535 pp., 7¼ × 5 in.

This formidable title leaves little room for saying anything else, even if a dictionary were not always the most hopeless kind of book to review; and one is always disposed to say of it, as the Scotchman did of Johnson's Dictionary, that it is "interesting reading, but hard to remember."

The book before us, as its title indicates, is more than a mere vocabulary with definitions. Many of the words and terms have dissertations on them occupying several pages. Thus, after the word "cupola" there is the definition: "A cupola is simply a foundry melting furnace," and then there is a fuller description of its construction, which occupies two pages. Many curious facts are given; thus, after the term "Damascus steel" it is said that "it is composed of layers of very pure iron and steel, worked with great care by heating and extraordinary forging, such as twisting, doubling, etc.," facts which probably few readers ever heard of before.

In looking over the interesting pages of this book the reflection is suggested, though, of how much more interesting it would be if it was well illustrated with engravings of the objects described.

The Effect of Brakes upon Railway Trains. By Captain Douglas Galton. Reprinted with a Preface by the Westinghouse Air Brake Company. 171 pp., 6 × 9 in.

The Westinghouse Company have done railroad engineers a service in reprinting the three papers which were read by Captain Galton before the Institution of Mechanical Engineers in 1878 and 1879. Those papers are not accessible to most readers, and by their republication they are now placed within the reach of all who desire to get them.

The circumstances under which these experiments were made are described as follows in a preface to the volume before us: A short time previous to the experiments, in a discussion at the Institution of Mechanical Engineers, Mr. Westinghouse called attention to the fact that "in testing the action of various kinds of brake shoes he had observed a very marked difference in the friction of the shoes upon the wheels at high speeds and at low speeds. He believed that a determination of the facts was of great importance, and volunteered to design and construct the necessary automatic recording apparatus, and to carry out a system of experiments under the direction of any person who should be appointed by the President of the Institution to supervise the tests and report to it. The Institution immediately took advantage of this offer of Mr. Westinghouse, and designated Captain Douglas Galton, who, on behalf of the Institution, personally directed the experiments. The success of the project became assured when the London, Brighton & South Coast Railway placed a locomotive and brake van at the disposal of Captain Galton and Mr. Westinghouse, and offered every facility for conducting the experiments."

The results of these experiments were afterward embodied in the three papers which are now reprinted. The mechanical work of the reprint is all admirable. There is only one adverse criticism to make—the paper of the book has a most horrible odor—a characteristic of some of the coated paper which of late has come into use so much. In reading it one in-*stink*-tively holds the book to the leeward, and longs for a bottle of disinfectant.

Asphaltum in 1893. By Clifford Richardson and E. W. Parker. Extract from the "Mineral Resources of the United States, Calendar Year 1893." Department of the Interior, Geological Survey, I. W. Powell, Director. Washington: Government Printing Office. 45 pp., 5¾ × 9 in.

Of this publication it may be said, generally, that it tells all about asphaltum, what is its amount of production, where it comes from, how it is produced, what it is used for, origin and history of the asphaltum paving industry, specifications for paving, life of such pavements, etc. The accounts of the sources of supply of asphaltum in California and Trinidad are especially interesting. Any one concerned in the subject will be amply repaid by reading this carefully prepared report.

THE NATIONAL SCHOOL OF ELECTRICITY. Prospectus. I. Allan Hornsby, Secretary, Chicago. In this announcement it is said that it is "the intention to organize a class in electricity in every city and town where the population will justify it." It is not assuring, though, to be told that "the course of study will occupy about one year, allowing for holiday seasons and *intemperate* weather," and "the tuition fee for the course will be $12.50." The names of a number of distinguished people are given as an "honorary faculty;" but what part if any they will take in the tuition is not told.

BRICK FOR STREET PAVEMENTS. *An Account of Tests Made of Bricks and Paving Blocks, with a Brief Discussion of Street Pavements and the Method of Constructing them.* New Edition, with a Paper on Country Roads. Prepared for the Engineers' Club of Cincinnati, April, 1894. By M. D. Burke, C.E. Cincinnati: Robert Clarke & Co. 108 pp., 6 × 9 in.

The origin of this pamphlet is explained by the author in his preface, in which he says that "a large part of the contents of it was contained in a report made to the village authorities of tests of material to be used in paving streets in Avondale, where the writer was employed as village engineer."

Sixteen different kinds of paving brick were tested. In making them "it was deemed advisable," the writer says, "to ascertain first the essential chemical ingredients; second, the ratio of absorption; third, the crushing strength; fourth, the transverse strength; fifth, the resistance to abrasion and impact." The results of these tests are very fully and lucidly described. Besides there are dissertations under the following headings: Statistics of Traffic and Durability of Pavements; the Probable Durability of a Brick Pavement; Municipal Methods; General Discussion of Pavements; What Shall be Specified; What has been Done; the Matrix; Where Should Brick be Used for Street Pavements; Maintenance; What is in a Name; Size of Paving Bricks and Country Roads.

Regarding the durability of brick pavement, the author concludes, from his abrasion tests, that the time required to wear an inch from the brick will be about 60 per cent. of that required to wear an inch from granite; and this, he says, "would seem to justify the belief that a brick pavement on Fourth Street, between Walnut and Race, in Cincinnati, should be in fair condition after ten years' traffic shall have passed over it."

The style of the book indicates that it was written by a person accustomed to deal with things and not merely write about them, and what he reports and discusses are the results of observations and are not "lecture notes," to which so much vapid technical literature owes its origin. The essay can be commended to all who want information about the subject—which is daily growing in interest—which it discusses.

COUNTRY ROADS—No. I. Edited and published bi-monthly by Isaac B. Potter, New York. 64 pp., 4¾ × 6¾ in.

Apparently, if we don't have good roads, it will not be for the want of literature on the subject. The above is a new candidate for public favor at 10 cents a copy and 50 cents a year. It is intended to give to people who need practical knowledge of road and street making, and who cannot afford to pay the prices commonly charged for scientific books, information in a convenient and attractive form at a merely nominal price.

This first number is certainly worth 10 cents, as the following sample of its contents will show:

"I say to every road-maker," the editor says, "it pays to think. There is money in it. . . . I believe that every citizen of this country who owns a wagon should paint in conspicuous letters on each end of it these words: 'He that hath brains to think, let him think.' If he will do this on the subject of country roads he will, perhaps, know what a horse knew years ago. . . . I have never," he says further, "had the heart to blame a kicking horse. It is the only way he has of stating his opinion—his one solitary method of filing an objection. When he kicks too much I always think of the other horses that don't kick enough; and I have seen it done under perfectly justifiable conditions—under circumstances of cruel provocation that would excuse manslaughter and justify an earthquake; and though the air was filled with splinters and profanity, I have had the happy satisfaction of seeing a dumb and patient brute deliver an eloquent and emphatic argument in behalf of downtrodden labor. The only beast that was ever know to talk is said to have called Mr. Balaam's attention to the bad going.

"If all the sixteen millions of farm horses in this country, all the faithful beasts that have become galled, and jaundiced, and wind-broken, and spavined, and foundered and mangy in our service, should make up their minds to balk and shy at every mud-hole, and, for every blow, to stand in their tracks and kick holes in the *firmament*, the question of better roads would be forever settled." (Copyright, 1894, by I. B. Potter.)

We agree with Mr. Potter that it pays men to think, especially if it enables them to write as he does; but whether it would pay sixteen millions of horses to think and begin "kicking holes in the firmament" is quite another question.

BOOKS RECEIVED.

ELECTRICITY ONE HUNDRED YEARS AGO AND TO-DAY. By Edwin J. Houston. New York: The W. J. Johnston Company, Limited.

THE ANIMAL AS A MACHINE AND A PRIME MOTOR, *and the Laws of Energetics.* By Professor R. H. Thurston. New York: John Wiley & Sons. 97 pp., 5 × 7½ in.

WEATHER-MAKING, ANCIENT AND MODERN. The *National Geographic Magazine.* Washington: published by the National Geographic Society. 28 pp., 6 × 9¾ in.

TWENTY-FIFTH ANNUAL REPORT OF THE RAILROAD COMMISSIONERS OF THE STATE OF MASSACHUSETTS. Boston: Wright & Potter Printing Company, State Printers. 600 pp., 5¼ × 8¾ in.

ELEVENTH ANNUAL REPORT OF THE BOARD OF RAILROAD COMMISSIONERS OF THE STATE OF NEW YORK, *for the Year* 1893. Vol. I. Albany: James B. Lyon, State Printer. 720 pp., 5½ × 8¾ in., with map.

PROCEEDINGS OF A NATIONAL CONVENTION OF RAILROAD COMMISSIONERS, *Held at the Office of the Interstate Commerce Commission,* Washington, D. C., May 8 and 9, 1894. Washington: Government Printing Office. 78 pp., 9 × 5¾ in.

ON METHODS USED AND RESULTS OBTAINED IN MAKING GERMICIDAL-EFFICIENCY TESTS OF A DISINFECTANT FOR USE IN RAILWAY SANITATION. By William T. Sedgwick. Boston: Beacon Press, Thomas Todd, Printer. 23 pp., 7 × 9¾ in.

TRADE CATALOGUES.

PRICE LIST OF PROFESSOR SWEET'S PATENT MEASURING MACHINES, Manufactured by the Syracuse Twist Drill Company, Syracuse, N. Y. 12 pp., 3¼ × 5¾ in.

The title of this "booklet" is of itself sufficiently descriptive. The measuring machines have a micrometer screw arrangement, and are made in sizes to measure up to 24 in. An excellent and well-illustrated description, showing the special features of the instruments, is given, with prices, sizes, etc.

OUR SHARE IN COAST DEFENSE. Part III. Builders' Iron Foundry, Providence, R. I. 16 pp., 6 × 9 in.

The purpose of this pamphlet is to give a description of the 12-in. spring return mortar carriages made at the Builders' Iron Foundry. An excellent half-tone engraving is given of one of these carriages, which was exhibited at Chicago, with outline engravings showing side and end views, and a plan of the mortar and carriage. In the description the publishers say that they have followed quite closely the wording of the report of the Government Inspector at the works.

SKINNER PATENT CHUCKS, Manufactured by the Skinner Chuck Company, New Britain, Conn. 48 pp., 6 × 9 in.

This company manufactures and have described in their new catalogue independent, universal, combination, and universal and combination lathe chucks, drill and planer chucks, and face-plate jaws, etc. These and their different parts are illustrated by over 70 wood-engravings and descriptions. The manufacturers write that they have added several new styles of chucks to their list. A new feature of their catalogue is that a number is provided for every style and size of chuck which they regularly make, whereby they can be ordered without going into detail.

AMERICAN TUBE WORKS, Boston, Mass. Seamless Drawn Brass and Copper Tubes. W. H. Bailey, Agent, 20 Gold Street, New York. 51 pp., 4½ × 7½ in.

There are perhaps few subjects so provocative of profanity to mechanical engineers as wire gauges. The American Tube Works have done something to lessen such infractions of the

moral code by giving, in a clear and concise form in the beginning of their catalogue, the sizes of the Stubs' and the Brown & Sharpe gauges. Elaborate tables are afterward given of the sizes and weights of the tubing made by this company, and the volume ends with some very convenient pages of cross-section paper for memoranda.

CONCERNING RED LEAD. National Lead Company, 1 Broadway, New York. Compiled by Ralph K. Wing. 29 pp., $5\frac{1}{4} \times 8$ in.

The purpose of this publication is to advocate the use of lead paints instead of other compounds. It gives first a description of what red and white lead are, and how they are manufactured. This is followed by extracts and reprints from various publications of articles on paints. These are brought together in convenient form, and give the results of the observation and experience of many persons with the use of paints under many different circumstances. The pamphlet is well worth possessing by those interested in the subject, and may be obtained by writing for it to the publishers.

THE VALUE OF TIE PLATES IN TRACK REPAIRS. An Analysis of the Dimensions, Form and Functional Purposes of Tie Plates. Read before the Buffalo Association of Railroad Superintendents, April 19, 1894. By Benjamin Reece. Published by the Q. & C. Company, of Chicago. 63 pp., $6 \times 8\frac{3}{4}$ in.

The purpose of this paper is indicated by the above title. It is an investigation, made by the author, to ascertain the value of tie plates under the rails of railroad tracks, and especially of the Servis Tie Plate, which has of late years been extensively introduced. The paper is well illustrated with a variety of engravings, showing the effects of the wear of rails on ties, and is a careful study of the subject and replete with information in which every engineer in charge of track is interested.

MODERN TURRET LATHE PRACTICE. Published by the Gisholt Machine Company, Madison, Wis. 12 pp., $7 \times 10\frac{1}{2}$ in.

This company has sent us the May and June numbers of a publication with this title, which contains half-tone engravings of the machines they make, and descriptions of the work which can be done on them. It is proposed to issue this publication monthly hereafter, which intention, no doubt, will be carried out for a short time; but it is safe to predict that the material required for each number will be exhausted before many months roll by. The machines are fairly well illustrated, and doubtless are capable of doing excellent work. The publication, as long as it is continued, will help to instruct mechanics with reference to the work which can be done on machines of this kind.

THE AERATED FUEL PROCESS OF BURNING OIL, for all Purposes for which Heat is Required in the Mechanical Arts. Gilbert & Barker Manufacturing Company, New York and Springfield, Mass. 56 pp., $6\frac{1}{4} \times 7\frac{1}{2}$ in.

Aerated fuel is crude mineral oil which is "atomized" by being fed through burners by a current of compressed air. The special apparatus which the Gilbert & Barker Company are making for this purpose is fully described in the circular before us, which is illustrated with engravings of the air compressors and the oil pumps and receiver which are used. The process is fully described, and a large number of testimonials are published, in which the opinions of those who have used the apparatus is given, and which are evidence of the extent to which this kind of fuel is now used.

A FEW PLAIN FACTS CONCERNING WATER-TUBE BOILERS. Information Pamphlet No. 3. Abendroth & Root Manufacturing Company, New York. 95 pp., $9\frac{1}{4} \times 6$ in.

This is a well-printed and elaborately illustrated pamphlet describing the well-known Root water-tube boiler. The description begins by telling us what the boiler is; next there is a statement of the claims made for it, in which its peculiarities and merits of construction are very fully described and illustrated; third, a chapter on the "Circulation in the Improved Boiler;" fourth, a "Few Special Words about Facilities for Cleaning," and last, a "General Description of the Improved Root Boiler." The publication is illustrated by over 30 wood-cuts and "half-tone" engravings, all of the very best kind. It is another illustration of the fact that the best technical literature now relating to many subjects may be found among trade catalogues.

BOSTON BELTING COMPANY, Boston, Mass. 116 pp., $3\frac{3}{4} \times 6\frac{1}{4}$ in.

In these days of industrial differentiation, one is constantly surprised at the amount of information there is to be acquired on all kinds of subjects. We have before us a new catalogue published by the Boston Belting Company, which, to use a boy's expression, is "chuck full" of information from one end to the other. There is, first, a short history of the company; then "facts relating to belting," followed by a long chapter of "suggestions for the transmission of power by rubber belting." After this are chapters describing the different kinds of belting, hose packing, valves, tubing, soling, springs, mats and matting and rubber rollers made by this company. Interspersed all through it is a great deal of valuable information which makes the catalogue a valuable acquisition for any mechanic or engineer who wants to be well up in information concerning these subjects.

THE MCSHERRY MANUFACTURING COMPANY, Manufacturers of Patent Lever, Screw and Ratchet Lifting Jacks, Dayton, O. 29 pp., $6 \times 8\frac{1}{2}$ in.

In this catalogue the manufacturers have illustrated and described nine different forms and sizes of lever jacks, which are operated by a lever and ratchet. These are intended for lifting buggies, carriages, wagons, threshing machines, portable engines, railroad cars and tracks and for wrecking purposes. Seven different kinds of screw jacks are also shown and described. These are designated as "building and bridge jacks," locomotive, coach, plug and foot-lift jacks, and are used for different purposes. Accompanying most of the illustrations of the complete jack, engravings of their different parts are shown, to facilitate the ordering of repairs. The illustrations are wood-engravings, which, though not of the best of their kind, are nevertheless very good.

BLOOMSBURG CAR COMPANY, Manufacturers of Freight, Mine and Dump Cars of Every Description, Bloomsburg, Columbia County, Pa. 55 pp., $6\frac{1}{4} \times 9\frac{1}{4}$ in.

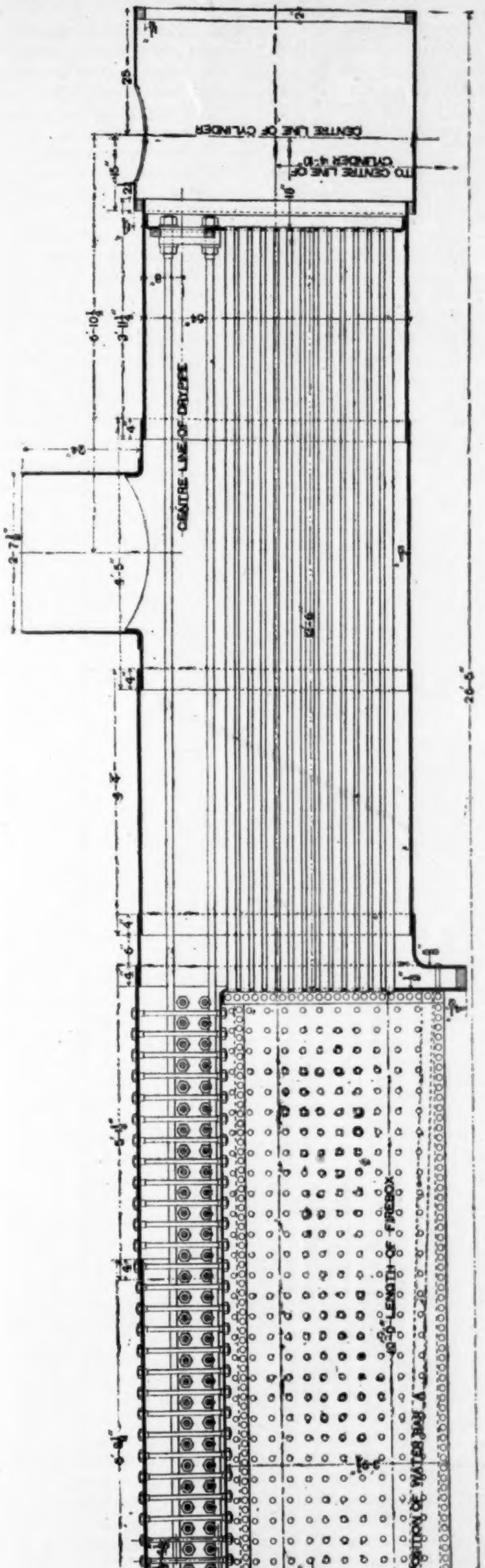
The great variety of freight cars which this company builds for different purposes are illustrated by very good wood-engravings in the new catalogue, which is before us. These include box, stock, gondola, hopper bottom, construction, flat and caboose cars for ordinary roads. Besides these, the company have manufactured a great many kinds of cars for special purposes, such as cars for narrow-gauge roads on sugar estates, dump cars of many kinds, and for a variety of purposes, mine cars of different kinds, hand and push cars, lumber trucks, etc. The company also makes wheels and axles and the beamless brake which is described and illustrated, portable beams, frogs and turn-tables for light railroads.

In their preface the publishers say they give "a general view of their works. These were first erected in 1868, and after being destroyed completely by fire in 1879, were rebuilt. To these, year by year, improvements and additions have been added, and new machinery has been introduced as fast as it was found to be necessary for the thorough equipment of the shops. The plant now covers over four acres of ground, and our shops alone cover two acres."

BELPAIRE BOILER ON THE LEHIGH VALLEY RAILROAD.

WHEN Mr. A. Mitchell was superintendent of motive power of the Lehigh Valley Railroad, he designed and put in use a Belpaire boiler with a wide fire-box, an engraving of which we give in this issue. The peculiarity to which we wish to call most particular attention in the boiler is the method of staying the back heads by running through braces, with nuts from the back head to the front tube sheet. The boiler is of such a width that it extends out over the driving-wheels, which are 4 ft. 1 in. in diameter. The rear driver stands at a distance of 4 ft. 6 in. forward of the back head of the boiler. The next one is spaced 4 ft. 5 in. ahead of this; both of these two rear drivers are therefore beneath the fire-box. As the boiler is used on consolidation engines, the other two drivers are located beneath the shell. The total driving-wheel base of the engine is 15 ft. 1 in. The pony truck stands 7 ft. $10\frac{1}{2}$ in. ahead of the front driver, so that the total wheel-base of the engine is 22 ft. $11\frac{1}{2}$ in. The total length of the boiler is 26 ft. 5 in., of which 3 ft. 4 in. is occupied by the smoke-box, 12 ft. 4 in. by the shell, and 10 ft. 9 in. by the fire-box.

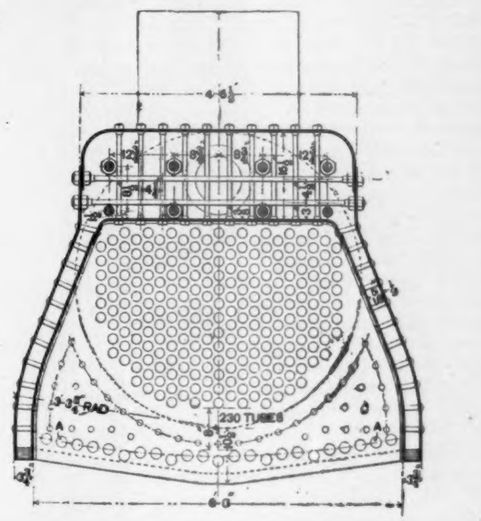
It would seem that the great length of the through stays running from the back head to the front tube sheet would cause them to vibrate and become loose in running; but inasmuch as these engines have been in service for some time and have given most excellent satisfaction, causing no trouble in this respect, we presume that the difficulty which most engineers would anticipate has not occurred. The fuel used is anthra-



BELPAIRE BOILER ON THE LEHIGH VALLEY RAILROAD FOR CONSOLIDATION ENGINE.

cite coal. The following are the specifications and the general dimensions of the boiler :

Inside diameter of smallest boiler ring	4′ 4″
Material of barrel of boiler	Steel.
Thickness of plates in barrel of boiler	½″
Kind of horizontal seams	Lap.
" " circumferential seams	"
Material of tubes	Iron.
Number " "	230
Diameter of tubes outside	2″
Distance between center of tubes	2⅝″
Length of tubes over tube plates	12′ 6″
" " fire-box	10′
Width " "	6′
Depth " "	3′ back. 3′ 5″ front.
Water space, side of fire-box	2$\frac{1}{16}$″
" " back " "	3″
" " front " "	4″
Material of outside shell of fire-box	Steel.
Thickness of plates of outside shell of fire-box	½″



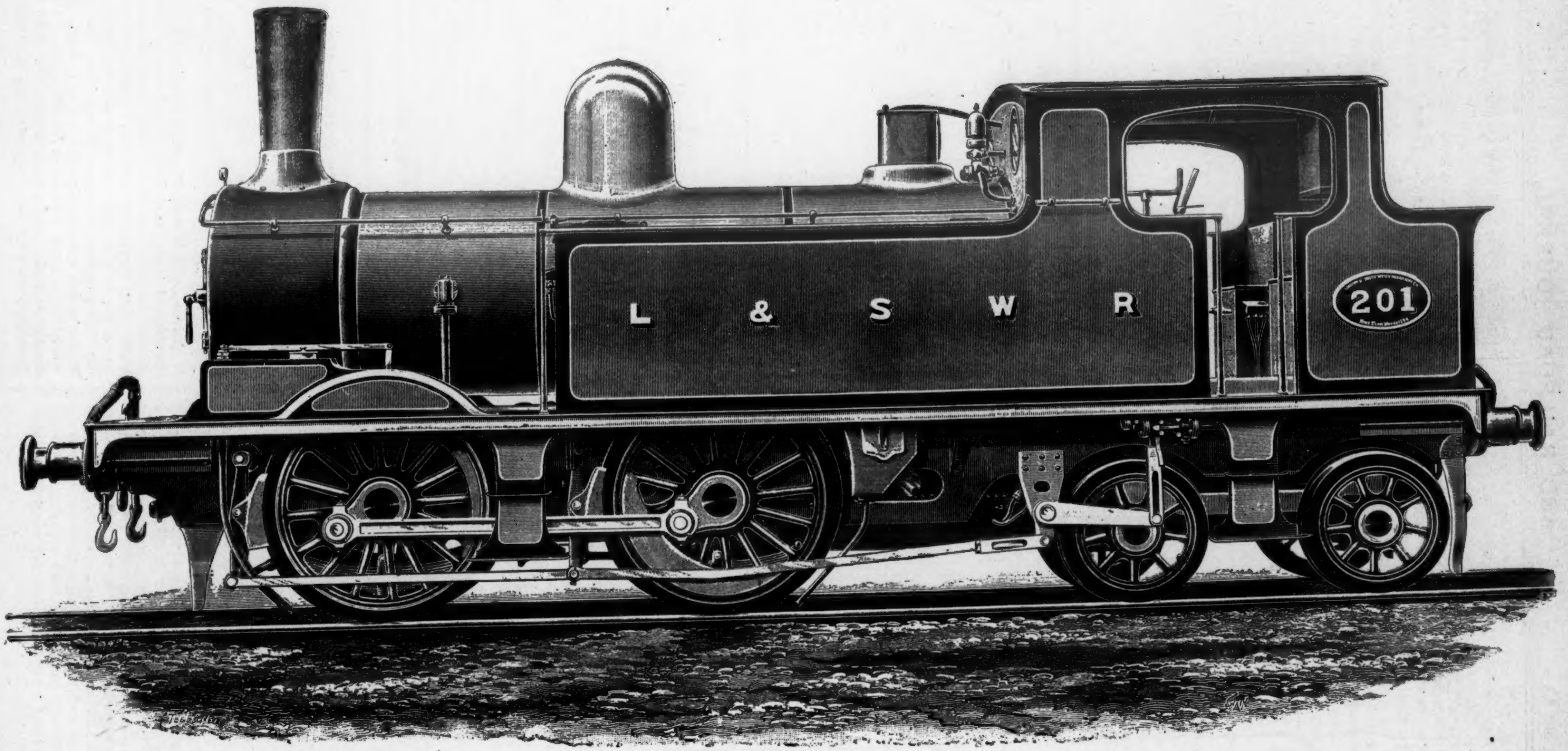
CROSS-SECTION THROUGH FIRE-BOX.

Material of inside fire-box	Steel.
Thickness of plates of inside fire-box	$\frac{5}{16}$″
" " " back end of fire-box	⅜″
" " crown-plate	⅜″
Material of tube-plates	Steel.
Thickness of front tube-plates	½″
" " back "	½″
Crown-bar staying	Belpaire stay-bolts.
Diameter of dome outside	2′ 7½″
Height of dome to top of sheet	2′
Maximum working pressure per sq. in.	140 lbs.
Kind of grate used	Drop bars.
Width of bars (or diameter of tubes of water-grates)	2⅛″ diam.
" " opening between bars or tubes	⅜″
Grate area	60 sq. ft.
Heating surface in fire-box	132.7 "
" " " tubes	1,437.87 "
Total heating surface	1,566.57 "
Kind of blast nozzle	Single.
Diameter of blast nozzle	4½″
Smallest inside diameter of stack	16″
Height from top of rails to center of boiler	7′ 1″

NOTES AND NEWS.

The "Cincinnati."—The cruiser *Cincinnati* is now in commission, although she is still in the hands of the mechanics. It is expected that she will be ready for a sea cruise shortly after the first of this month. The dock trials of the engines took place a few weeks ago, and were very satisfactory.

Corrosion of Water Pipes.—Considerable interest has been manifested lately, especially in the neighborhood of Boston, in the corrosion which has been brought about in gas and water pipes through the effects of electrolysis arising from the use of the rails on street railways for the return current where the trolley system is in use. It was found that the electrolytic action which was destroying the gas in water pipes occurred where the current entered or left the pipes. Various suggestions were made in order to overcome this. One was to connect ground plates with the man-holes, and so transfer the electro-



FOUR-WHEELED COUPLED TANK LOCOMOTIVE ON THE LONDON & SOUTHWESTERN RAILWAY.

lytic action to these plates. Insulation of the cables and pipes was also proposed, but nothing satisfactory has yet been devised to overcome the difficulty.

Trial of Harveyized Armor Plate.—A recent trial of Harveyized armor plate made by the Bethlehem Iron Works was made at Indian Head, the plate subjected to the test being 77 in. in thickness and made of nickel steel. It was one of the group intended for the barbettes of the battleship *Massachusetts.* A 12-in gun was used and two shots were fired. The first shot was at a velocity of 1,401 ft. per second, with a penetration of 6 in. or 7 in. The point of the projectile was welded into the plate and the base of the shell demolished. No cracks were developed and there was no disturbance. The second shot was fired at a velocity of 1,858 ft. per second. The shell is estimated to have entered the plate 10 in. or 11 in., the point remaining in the plate welded as in the first shot. The remainder of the shell was badly broken. In the second shot a fine crack was developed. It extended from the point of impact to the nearest edge. It was believed to extend through the plate, although it did not open up the target, and there was no suggestion of the huge opening which was created by the initial shot on the 18-in. plate. The results were entirely satisfactory, and will suffice to pass the materials on firing. The projectiles used were of the Carpenter type, and apparently up to the standard quality.

Four-Wheeled Coupled Tank Locomotive on the London & Southwestern Railway.—In our issue for April we published drawings and a description of a four-wheeled bogie tank locomotive that is used on the London & Southwestern Railway, which was designed by Mr. W. Adams, Locomotive Superintendent. On another page we publish a full-page engraving giving the side view of this engine, for which engraving we are indebted to the *Engineer* of London. This engraving gives a very good idea of the appearance of the engine on the road, and, coupled with our description as published in April, is sufficient to enable an engineer to reproduce the engine if he should so desire. We wish, however, to call particular attention to the broad and safe steps which are used and which characterize English locomotive practice in general, and also the arrangement of the driver brakes, in which there is no apparent compensation for variation in the wear of the shoes, in which all are brought to bearing before the breaking resistance really begins.

Testing the Dryness of Steam.—At a meeting of the Institution of Engineers and Shipbuilders in Scotland, Mr. Strohmeyer explained the method of testing the amount of moisture in steam, devised by Mr. C. J. Wilson, of University College, London. The principle, which is more particularly applicable to marine engines, consists in comparing the saltness of the steam with that of the water in the boiler. The test is carried out by means of nitrate of silver, and the reaction is so delicate that with only 1 per cent of salt in the boiler, 1 per cent of priming water can be accurately determined to the second decimal. The process is as follows: To 1 part of salt boiler water there is added 100 parts of pure condensed water, and into this there is poured a small quantity of concentrated solution of yellow chromate of potash. Then a nitrate of silver solution containing about one-tenth per cent. of this salt is slowly added. With each drop the salt water turns locally orange red, but this color disappears at first; later on, when all the salt has been acted on, the whole fluid changes color from pale yellow to orange. The quantity of nitrate solution is noted, and then the experiment is repeated on the condensed steam from the engine, undiluted with distilled water. The ratio of the quantities of nitrate of silver solution used in the two tests expresses the amount of priming in per cent.

The Fastest Ship in the World.—Under this title the *Engineer* gives some data in regard to the recent trial of H.M.S. *Daring.* This vessel is a torpedo-boat catcher, and was built by Messrs. Thornycroft & Co. In the mean runs over the Admiralty measured mile on the Maitland sands, she reached the unprecedented speed of 28.6 knots, the last of the three runs occupying only 2 minutes 3 seconds, which is equivalent to a speed of 29.3 knots. The *Daring* is the first of five torpedo-boats and destroyers in course of construction by Messrs. J. I. Thornycroft & Co., to form a part of the new destroyer flotilla which is the latest department in the Admiralty naval policy. The dimensions of the vessel are: Length, 185 ft.; beam, 19 ft.; and draft, 7 ft. These vessels have been designed for the purpose of overtaking torpedo-boats and destroying them by shell fire, and for this purpose a considerably higher speed than that of a first-class torpedo-boat is required, so that the guaranteed speed is 27 knots, to be obtained for a continuous 3 hours run at sea. They will be armed with 6 quick-firing guns of different calibers, and provision is made for fitting them as torpedo vessels if required. The largest size of the destroyers, as compared with the torpedo-boats, enables them to maintain their speed made in rough water, and to make it more difficult for the torpedo-boat to escape. The Thornycroft boats are fitted with a special system of double rudders, which give them exceptional manœuvring power, and enable them to be steered astern quite as well as ahead. This was decided on a measured mile, so that these greyhounds of the sea can double and turn as fast as the hares they pursue. The indicated H.P. is estimated from 4,800 to 4,900.

Women in Railway and Postal Service.—*Le Journal des Transports* recently had an item in regard to women in railway and postal service, and stated that women were first employed in France in post-office work. This, it seems to us, is a little doubtful, as they have been employed for many years in the postal service of the United States; but however that may be, the article goes on to state that the attempt has given such good results that some prefer women to men when the substitution is possible. In the United Kingdom women comprise 25.2 per cent. of the employés of the postal service, with the exception of the porters, who are not included in the estimate. In Switzerland women compete with men for various places in the postal and railroad service. They are very numerous in both telegraph and telephone work. In Holland eight groups only in the postal and telegraph service are open to women; 720 are engaged in railway work. The number of women working in the post-offices of Italy is very small; but in Spain they occupy almost all of the office positions in telephone work, and the Government has under consideration the proposition to increase their number in telegraph offices. In Switzerland women are more numerous than men in telegraph work, and they are admitted to all kinds of postal service with the exception of that of porter. In Norway and Denmark women have the same standing as men and the same salaries in the postal and telegraph service. In Denmark they can even occupy the position of head of department, and are admitted as stenographers in Parliament. Women are admitted to public employment on the most liberal terms in Finland. They occupy many positions in Germany, Austria, Roumania, Russia and in the English colonies. In Brazil they are admitted to government employment. In the United States of Colombia a special telegraph group has been established for them; finally, in Chili they not only occupy positions in the postal and telegraph service, but actually monopolize the position of street railway conductors.

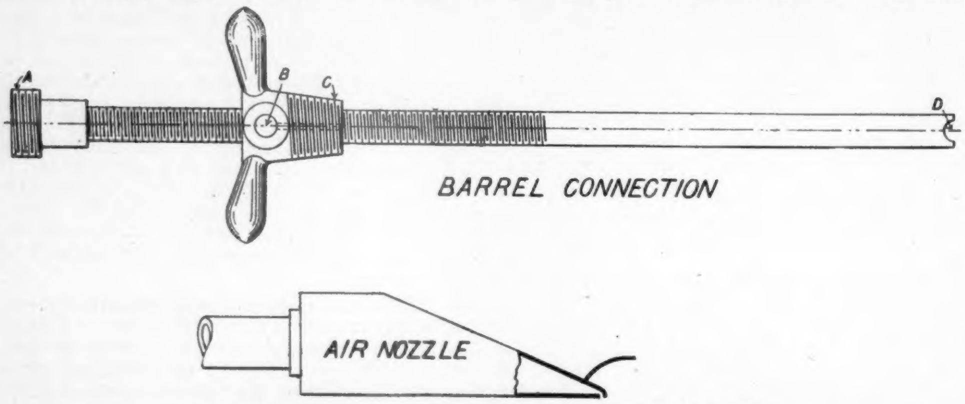
The Expense of Electric Lighting with Gas Motors.—In a paper read before the Industrial Society of Northern France, after having given a *résumé* of experiments by which he demonstrated that more light could be given by driving dynamos with gas motors than by burning the same quantity of gas in burners, M. A. Witz showed that the gas companies have been induced to establish central electric lighting stations in order to break their threatened monopoly. The initiative of this movement was taken in Germany, but there are at the present time 16 stations driven by gas engines in France. These are connected to gas works, so that these stations permit the companies to retain their patronage, while they would lose it if they persisted in offering them nothing but gas. M. Witz estimated in a general way that under these conditions a hecto-watt of light could be sold for 2 cents, while still making insufficient profits, and he arrived at these figures after a detailed and careful examination of the expenses of operation, interest and depreciation. But there would still be a considerable advantage for consumers of light if they organize groups among themselves for installing special stations that would serve isolated dwellings in the wealthy quarters as well as cafés, hotels and large stores, while a certain number of houses, by forming a syndicate, could obtain light at a low price; it is sufficient for this purpose to set up a motor and dynamo in the center of some thinly settled locality. An annual lighting of 150,000 lbs. with lamps of 16-candle power places the cost of a hecto-watt at 1.07 cents when gas costs 3 cents a cubic meter (1.3 cub. yds.), 450,000 lbs. lowers the expense to .84 cents, and it falls to .65 cents when the amount of light used amounts to 1,500,000 lbs. These figures are based upon complete details, including interest and depreciation at 15 per cent., without profit; they are very low, because the mains leading to the isolated point are usually of more length. The facilities with which a gas motor may be set up are such that it is usually preferable to use it rather than steam engines, whose boilers and stacks would not always be tolerated in the better quarters of a city. When gas is too high in price the motor can be fed with a poor gas like the Dawson or some other, in which case the numbers of hecto-watt would diminish still more. M. Witz cites numerous cases of this kind with special stations, to which he calls the attention of all those who can obtain a

right to establish them, from the gas producers. The gas motor has introduced a new element into the struggle between gas and electricity, and it furnishes a defensive arm to gas companies and to their competitors; but it also puts into the hands of light consumers means of resisting the exactions of certain electric companies.

Coal Washing.—At a recent meeting of the Leeds Association of Engineers a visit was made to the Middleton colliery, where a coal-washing plant is in operation. This plant is the invention of a Westphalian, and by means of it seams that contain from 20 to 25 per cent of dirt can be worked so as to produce coal of a marketable quality, while under normal conditions it would be impossible to work them to a profit. The coal to be washed is lifted to a height of 85 ft. by an elevator at the rate of 75 tons per hour, and tipped into a revolving multiple drum screen, by which it is separated into five different sizes—viz., trebles, doubles, singles, peas and coking dust, the latter running through a $\frac{5}{16}$-in. mesh. The four larger sizes are carried down separate channels by means of water currents into the jigging or washing machines, in which the water is agitated by compressed air at $1\frac{1}{4}$ lbs. pressure per square inch, introduced and exhausted by means of piston valves, actuated by eccentrics. The unwashed coal rests upon wire gauze sieves, and the agitation sorts it into upper layers of coal, and lower ones of clay slate or dirt. The waste material forming the lower layers passes under slides to the bottom of the jiggers, and is drawn off to an elevator by spiral conveyers, the elevator delivering it to a hopper, whence it is carried away in trucks. The coal which forms the upper layers is floated by the water over the slides into iron culverts, and carried to masonry hoppers containing water, which prevents breakage of the coal as it falls to the bottom. When full of coal the water is drawn off, and the coal, after standing a very short time for draining, is dropped through sliding doors direct into the railway trucks. The water bringing the coal to the hoppers, which is continually overflowing and being drained off, is conveyed to large settling tanks, where the fine coal in suspension is allowed to settle, and finally sent to the coking ovens along with the small coal under $\frac{5}{16}$ in. in size from the multiple screen drum, after the latter has been passed through a Carr's disintegrator.

Use of Petroleum on Locomotives.—It is well known that the Great Eastern Railway of England has been using petroleum for a number of years on its locomotives, the engine which has been most widely illustrated and known in connection with this matter being the locomotive *Petrolia*. Recent reports show that it has been for some time hauling a train of 16 coaches on a consumption of 12 lbs. of liquid fuel and 10 lbs. of coal per mile. The regular cost of oils used is $5.04 per ton, while the coal costs $3.48. With these figures as a basis it is found that it has cost 4.25 cents for each mile run when coal and oil were used, against 5.48 cents when coal was the only fuel, thus effecting a fuel saving of about 29 per cent, or 1.23 cents per mile. There is also an additional saving in handling. It seems strange to advocates of oil fuel that the use of petroleum has not made more rapid advances on locomotive work in this country; but recent tests on the Chicago, Burlington & Quincy Road show that when oil is at 1.7 cents a gallon, and coal at $2 a ton, the cost is about the same. If oil drops or coal rises in the relative scale of prices, then oil becomes the cheaper. Making a comparison between our American figures and those given for the English engine, we find that, taking the ordinary fuel oil as supplied to the locomotives, there would be about 500 galls. to the ton, making it cost $8.50. It will, therefore, be seen that the English oil, being nearly $3.50 per ton cheaper than the American oil, while the coal is $1.50 more expensive, the saving of oil on the English engine is very much more marked than it would be in America. If we transfer these figures to the Southern California Road, for example, which intends taking up the matter of fuel oil, where the oil costs about $1\frac{1}{4}$ cents a gallon and coal is from $6 to $8 per ton, the saving will be correspondingly great. In round numbers and for rough estimates, it may be stated that when coal costs 120 times as much per ton as the oil costs per gallon, the expense is about the same. If this ratio is increased oil will be the cheaper. If it is decreased, coal will be the cheaper.

The Use of Compressed Air on the West Shore Railroad.—It has taken some time to find it out, but now that the adaptability of compressed air to all sorts of shop uses has been demonstrated, the railroads are rapidly falling into line. At the West Shore Railroad shops, in New Durham, N. J., there is a compressing plant which supplies air for emptying the oil from the barrels into the tanks; and we illustrate the barrel connection with which the work is done. This is a somewhat simpler arrangement than that illustrated in our July issue in connection with the report of the Master Car Builders' Association on Compressed Air Appliances and Hydraulic Machinery. It consists of a piece of extra heavy gas pipe long enough to reach through the bung-hole and rest upon the bottom of the barrel. It is threaded for some distance down from one end, and this thread carries an air connection with a taper thread upon the outside of the same pitch. This piece *C* has a boss, *B*, to which the air hose is attached, a small hole shown by dotted lines leading down to the barrel from *B* when *C* is screwed into the bung-hole. The hose leading to the tanks is screwed on the end of the pipe at *A*. Thus, when air is admitted at *B* it forces the oil through the slot *D* in the bottom of the pipe and out at *A*.



COMPRESSED AIR ATTACHMENTS, WEST SHORE RAILROAD.

At Weehawken there is another compression plant consisting of two Westinghouse air pumps with pipes leading down between the storage tracks at the depot. This air is used for car-cleaning purposes, and serves with three men to clean about eight cars a day. The nozzle used differs somewhat from those illustrated by the M. C. B. committee, in that the man in charge finds that an opening in the box directly downward gives better results than when it has a forward draft. The hood over the nozzle has also a slightly greater curvature. It is also found that a straight slot across the nozzle gives better results than one where the current of air is interrupted by rivets or other bracing for the flat sides of the nozzle.

The Worst Railway in England has recently formed the subject of correspondence in our daily papers. We thought it was a generally admitted fact, quite beyond dispute, that the Southeastern & London, Chatham & Dover railways easily took the prizes for dirt, bad stations, rolling stock, unpunctuality and disgraceful accommodation generally. However, some give the Southeastern Railway the first place, while others consider "honors equally divided." The following are some pithy views on one or both of these shameful systems, expressed by correspondents:

"The Southeastern Railway is the very worst railway in the world. Its engines are asthmatic; its lamps are trimmed by foolish virgins; its fares are excessive; its carriages let in snow in winter and are furnaces in summer. Its motto is unpunctuality; its principal station is approached through the neck of a bottle. It ruins the temper, destroys the digestion and enables one to realize the horrors of Dante's Inferno."

"What wonder, then, that all women in Kent are gray-haired, and all the men bald and given to the use of strong language?"

"Of course the Southeastern Railway; but its faults are mostly those of sheer 'cussedness.' Some time ago a main line train was 40 minutes late at Paddock Wood (I think), and in answer to more delay and playing at engines—the Southeastern Railway's favorite game—I was told by the inspector that two fish wagons had got into the middle of the train by mistake. The ticket snippers and collectors, upon whom the

management wastes thousands a year, have at Cannon Street such wretched lights that they cannot possibly spot the right half of a ticket, and the next day there are ructions! At Canterbury I once asked a porter what time a certain train was due; his answer was, 'So and so; but if you are here about 40 minutes late you will be in plenty of time!' Could not the London & Northwestern Railway spare a signal boy to put a lot of such simple matters straight? Or would the system of the Havant Line to Hayling work better, where a passenger puts up the stopping signal and buys his ticket on board? As to lights, foot-warmers, rickety engines, etc. Bah! Yours miserably, etc."—*Invention.*

Swiss Railways.—In Switzerland the use of metallic ties has advanced more rapidly perhaps in proportion to the number of ties used than in any other country, if we trust to the figures which are given by the Schweizenische Bauzeitung. The following is the proportion for five main lines—the Central, Gothard, North Eastern, Jura-Simplon and the Union. The proportions of metallic ties and of wood are given, as well as those of steel and iron rails.

	Central.	Gothard.	North-Eastern	Jura-Simplon.	Union.	Total.
Metallic ties	60.1	57.7	39.8	33.1	17.9	41
Wooden "	37.9	42.3	60.2	66.9	82.1	59
Steel rails	65.9	95.1	73.9	72.4	75.7	74.8
Iron "	34.1	4.9	26.1	27.6	24.3	25.2

On secondary lines fewer metallic ties are found. Nevertheless, some of them use them, and certain lines are equipped exclusively with them. Among others are several rack lines such as the narrow gauge lines of Appenzell, the one from Neufchatel to Boudry, and the electric road from Sissach to Gelterkinden, etc.

During the past few years the increase in speed and the weight of the engines has led to the use of heavier rails, so that the St. Gothard, laying rails of 101.0, 99.8 and 95.5 lbs. per yard, running over distances of 27, 26 and 10¼ miles, where the Jura-Simplon Railway has 91.1 lbs. per yard rails for a distance of 51½ miles.

At the end of 1893 there were 2,222 miles of railway of all kinds in Switzerland, of which 1,640 miles were main lines operated by the Swiss companies, 39¾ miles were main lines operated by foreign companies, such as the Baden, Alsace, Lorraine, Paris, Lyons & Mediterranean, and the Mediterranean of Italy, and the Eastern State Railway; 186 miles of secondary lines of standard gauge; 184 miles of narrow-gauge lines; 93 miles of mixed railways using both adhesion and the rack; 4 miles electric lines; 49 entirely rack lines; 26 miles tramways, and 9 miles of cable lines.

Coal in Mexico.—In discussing the matter of compound locomotives it is frequently stated that there is no doubt whatever that they would show a remarkable saving and be very advantageous to use in cases where coal is expensive, as in Mexico, where the road runs from $16 to $18 a ton. In view of this fact, it has seemed strange to some of our readers that our monthly locomotive reports of coal consumption give the cost of coal on the Mexico Central Railway in the neighborhood of $4.25. In order to explain this discrepancy, we addressed a communication to Mr. Johnstone, the Superintendent of Motive Power, asking for an explanation, and adding that the only way which suggested itself to us was that the coal was bought in the United States, imported into Mexico free of duty, and that the railroad charged themselves nothing for transportation. In reply to our inquiry, we have received the following communication from Mr. Johnstone:

"The discrepancy in the value of coal between our monthly statement and the actual cost of coal in Mexico is accounted for just as you have supposed. We buy this coal under contract in large quantities in the United States; it is delivered either at El Paso or at Tampico for about $4.50 per ton American money; but this same coal, when it is hauled to points near Mexico City and consumed by the compound engines on the mountainous section of this road, actually costs the company from $16 to $18 Mexican currency. As you say, the company makes no charge for the haul, and, while our official performance sheets are made out in Mexican currency, they are reduced back to American money for the small exchange sheets, a copy of which I send you. It is rather unsatisfactory to make out these exchange sheets in American money, as the rate of exchange varies from day to day; and, while we pay our men in Mexican money the same rate per kilometer run month after month, in reducing to American money the rate changes, due to the difference in exchange. I am thinking seriously of suggesting to the management that we make out these exchange sheets in Mexican currency and in kilometers."

The Agricultural Machinery in Southern Russia.—Recent British Foreign Office reports contain some interesting and valuable information on this subject, which bears upon the American and English exports to Southern Russia. Last year at Taganrog the trade in agricultural machinery, owing to the abundant harvest, was extremely satisfactory. In some cases the demand exceeded the supply, and most of the stores sold their stocks before the end of the season. As usual, the engines and steam threshers were English, the increase of the sales being large. Binders and reapers came from America, as did half the drills. The other half were of Russian make. A large number of Russian mowers were used for cutting hay, being well suited for the purpose, with the result of diminishing the American import. The trade in plows was the same as in the previous year, the larger amount sold being of Russian manufacture. The district of Berdiansk is studded with small engineering works engaged chiefly in the manufacture of agricultural machines and implements, most of them having their own foundries. These have all sprung up within the last eight or ten years, and this branch of industry is advancing with rapid strides. At the town of Berdiansk there is the largest reaper manufactory in Europe, capable of turning out 3,000 machines annually. The bulk of the pig used is Russian, as also a great part of the bar iron. Most of the steel and other materials are imported from England, America and Germany. One well-known American house has entered into contracts to supply a considerable amount of knives and other parts of reapers for the 1894 season. The reapers made here are of a type specially adapted to the country, and not found elsewhere. Their prices, $75 to $85, bring them within the reach of the small agriculturist; the simplicity of their construction adapts them to the wants of farmers, and at the same time brings them within the power of the light Russian horses. They are durable, and get through more work than the heavier and more complicated English and American machines. That they are better suited to the wants of the country is evident by the yearly output, which within a short time has increased from a few hundreds to 20,000, while the import of American and English reapers decreases. The manufacturers are continually adding to their plant; but the best makers have never yet been able to meet the continually increasing demand. They started originally to supply the wants of the local agriculturists, but as their machines became more known, orders came from all parts of Asiatic and European Russia. They are exported to Bulgaria and Roumania, and sent nearly all round the world to the Pacific coast of Siberia. Nearly all the machine factories in the district of Berdiansk are enclosed in a circle of 70 miles radius from that town. In addition to the foregoing factories and works, nearly every village in this district has its small makers of farmers' wagons and plows. Although the work is turned out in a primitive fashion in small workshops, with the simplest of blacksmiths', joiners' and wheelwrights' tools, it is of very good quality.

Tests of Machine Guns.—The tests of the machine guns at the Washington Navy Yard recently were marred to a great extent by defective ammunition. Because of the failure of the cartridges to explode properly, the Driggs Ordnance Company was compelled to withdraw its Accles gun from the competition until it could obtain better ammunition. The smokeless powder used in the cartridges for the Accles gun is of the nitro-glycerine character and the primers used were not sufficiently powerful to explode it. The Maxim-Nordenfeldt cartridge, especially prepared for the Maxim-Nordenfeldt gun, seemingly failed to work properly, a portion of its head and base being pulled off after it had been fired, leaving the remainder of the base in to be telescoped by the next cartridge inserted into the barrel. In consequence, the results that should have been obtained from this gun were not gotten. The board which is conducting the tests consists of Commander Charles Sperry, Chairman; Professor Philip R. Alger and Ensign Albert C. Dieffenbach. The competition was inaugurated with the test of the Maxim gun, which, after it had undergone an examination, was fired 100 rounds to determine its general action, this being followed by another 100 rounds fired for rapidity, the time being 10 seconds. The gun was then clamped, and, starting with the gun empty, another 100-round trial was fired, time being 16 seconds; 200 rounds were next fired in $25\frac{1}{10}$ seconds; 300 rounds in 40 seconds, and a full charger of 20 rounds in 6 seconds.

An army target was then placed inside the butt at a distance of 25 yards and 40 rounds fired. In this last trial a stoppage was noted, but the rounds completed to find the dispersion.

It was caused by the pulling off of the head of a case and leaving the front part of the case in the chamber. This caused the next cartridge to telescope the part left in the chamber, but the mechanism was cleaned by removing the lock. The time consumed in firing 30 rounds was $9\frac{2}{10}$ seconds. The gun was unclamped and the test repeated, the 40 rounds being fired in $15\frac{2}{10}$ seconds. Another part of the programme was clamping the gun and firing for $\frac{1}{2}$ minute, the number of rounds fired in that time being 127. The gun was unfastened, and 222 rounds fired. In firing 100 rounds deliberately, every fifth cartridge being a dummy, to test the effect of a miss fire upon the action, the gun worked all right, but instead of the machine firing the dummy it required to be fired by hand. Supposing that in service a lock might be disabled or extractor or firing pin broken, those parts were taken out, though in good condition, and replaced by others to test time required to do so. It took $15\frac{4}{10}$ seconds to do this. The Maxim gun was then laid aside to be further tested at Indian Head, and the board proceeded to examine the mechanism of the Gatling gun. This gun was put upon the stand on Monday. While firing the third plate it became jammed, but was quickly remedied. In firing 100 rounds more rapidly, the 81st shot jammed as before. The gun was clamped and 100 rounds fired in $10\frac{8}{10}$ seconds. Another jam occurred while firing 200 rounds, which was accomplished in $25\frac{4}{10}$ seconds. While firing 300 rounds a cartridge dropped off each plate, and two jams occurred. The time was 1 minute $12\frac{6}{10}$ seconds. Another jam took place in firing a charge of 20 rounds. The crank was shipped to the rear, and the 40 rounds fired with another jam, resulting in a flattened cartridge. Another jam occurred on firing 80 rounds, and four more in firing 100 rounds. The crank was removed to the side, and the gun unclamped, and with an addition of another man to the crew, 40 rounds were fired all right in $5\frac{6}{10}$ seconds. Eighty rounds were fired in $9\frac{6}{10}$ seconds, and 100 rounds in 15 seconds, including a stoppage of the feed for $1\frac{6}{10}$ seconds. The crank was again changed, and 40 rounds fired in $7\frac{4}{10}$ seconds; 80 rounds in $9\frac{6}{10}$ seconds. Another jam occurred while firing 100 rounds. The time consumed was over 20 seconds.

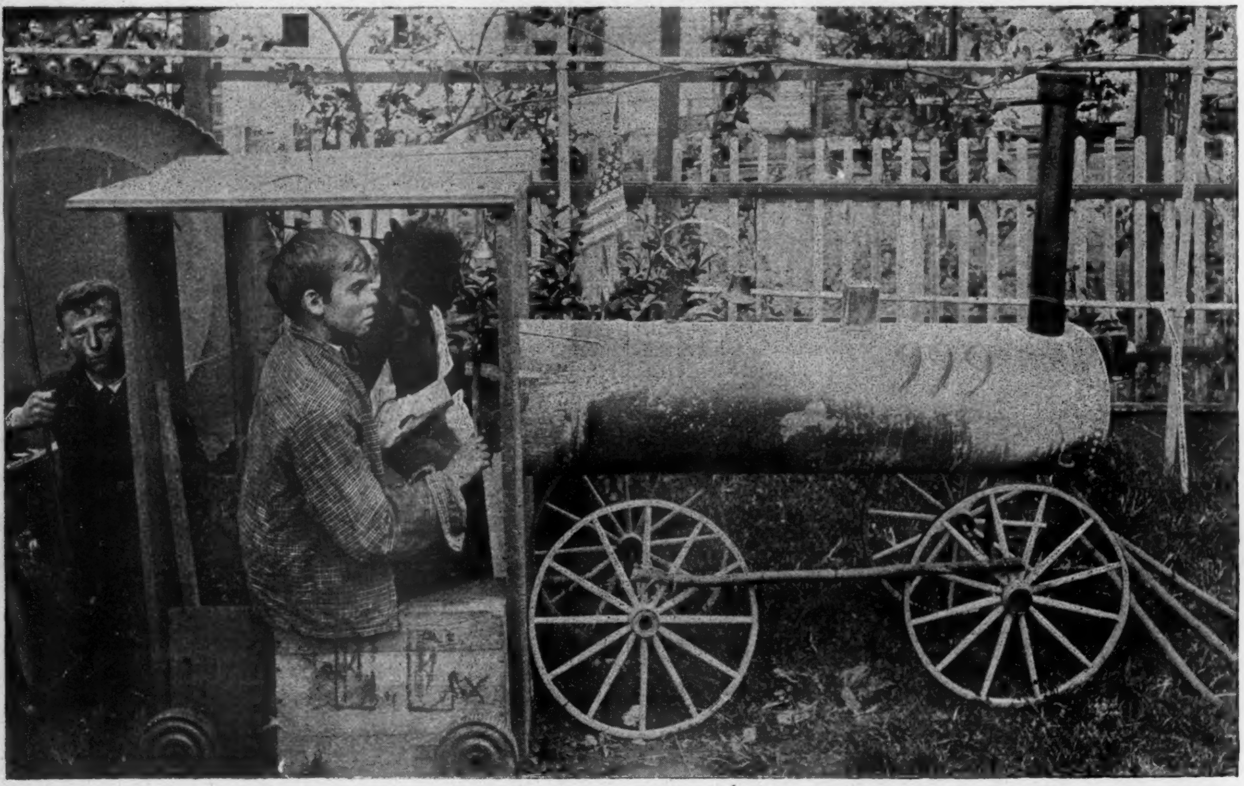
The Accles gun, controlled by the Driggs Ordnance Company, was brought from the pattern shop and 100 rounds were fired to test the action of its mechanism. The gun was manipulated by a crew from the yard. The shots went well for awhile, but it was soon noticed that defective ammunition was causing several stoppages. When 100 rounds were being fired to test the rapidity a couple of cartridge heads pulled off.

The following programme was then carried out up to noon: Firing into butt for rapidity, with the gun clamped and gun empty to begin with. This firing was done in charges of 100 rounds, 200 rounds, 300 rounds and a full charge of 25 rounds. In spite of the several delays occasioned by the bad ammunition, the best record so far was made when shooting at the targets. An army target, 6 ft. × 6 ft., at a distance of 25 yards, was fired at in charges of 40 rounds, 80 rounds and 100 rounds. The crew was firing at the target as above, with the gun unfastened, when the board took recess for dinner. An examination of some of the cartridges showed that the heads had pulled off, and in several instances holes $\frac{1}{16}$ in. wide and 1 in. long had been torn in the side of the shells.—*Army and Navy Journal.*

A NEW 999.

PROBABLY there was nothing at the Chicago Exhibition last summer which so thrilled the hearts of the masculine portions of the rising, and some of the risen, generations as the celebrated locomotive 999 did. That it left a permanent impression on the mind of at least one boy is shown by our illustration of his attempt to imitate this celebrated locomotive. Probably there are few of our grown-up readers who will not sympathize with him and his evident earnestness and assumption that he is engaged in serious business. He has apparently robbed the baby carriage of its wheels, the kitchen range of its boiler, the drain of a sewer pipe, and appropriated a soap box for the seat in the cab, and of these he has created another 999. It is true that the original machine will go and the new one won't; but what of that? Our young mechanical genius has the capacity which such old coveys as you and I, dear reader, have lost long ago—he "can make believe a great deal." His imaginary run with his locomotive is a much more real thing to him than any actual journey could be to us old and jaded reprobates, on whom the sun shines each year with diminished splendor, and to whom the past always has a flavor of dust and ashes, and who are unable to contemplate the future without apprehension. The run which our young hero in imagination has before him has no curves nor grades; he expects his engine will always have steam enough, and does not anticipate any collisions or derailments. May his illusion last as long as possible.

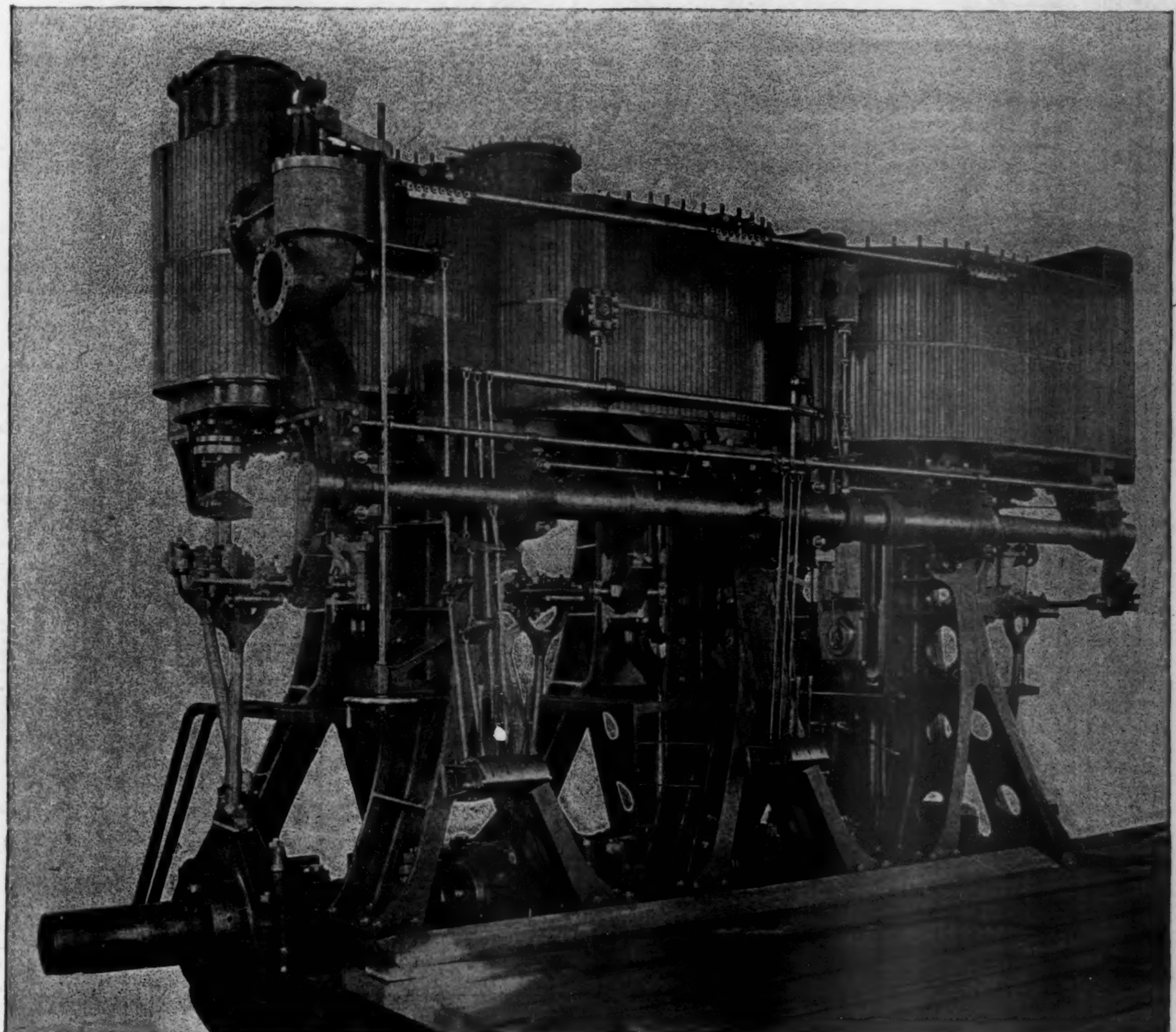
In our reflective mood we forgot to say that the young mechanical engineer who was the author of the new 999 is Henry Huss, Jr., of Mount Vernon, N. Y.



A NEW 999. BY HENRY HUSS, JR., MOUNT VERNON, N. Y.

TRIPLE-EXPANSION ENGINES OF THE UNITED STATES BATTLE-SHIP "TEXAS."

In our issue for May we published a description of the boilers and feed pumps of the United States battle-ship *Texas*, and now present a set of engravings illustrating the propelling engines which are used. These engines are rights and lefts, and are placed in water-tight compartments separated by a fore-and-aft bulkhead, this being the only fore-and-aft bulkhead in the vessel, as we have already explained in our issue for March. The water-tight compartments here run longitudinally through the length of the boiler and engine space, or a distance equivalent to the length of the armor plate. Aft and forward of these points the vessel is divided by transverse bulkheads only.



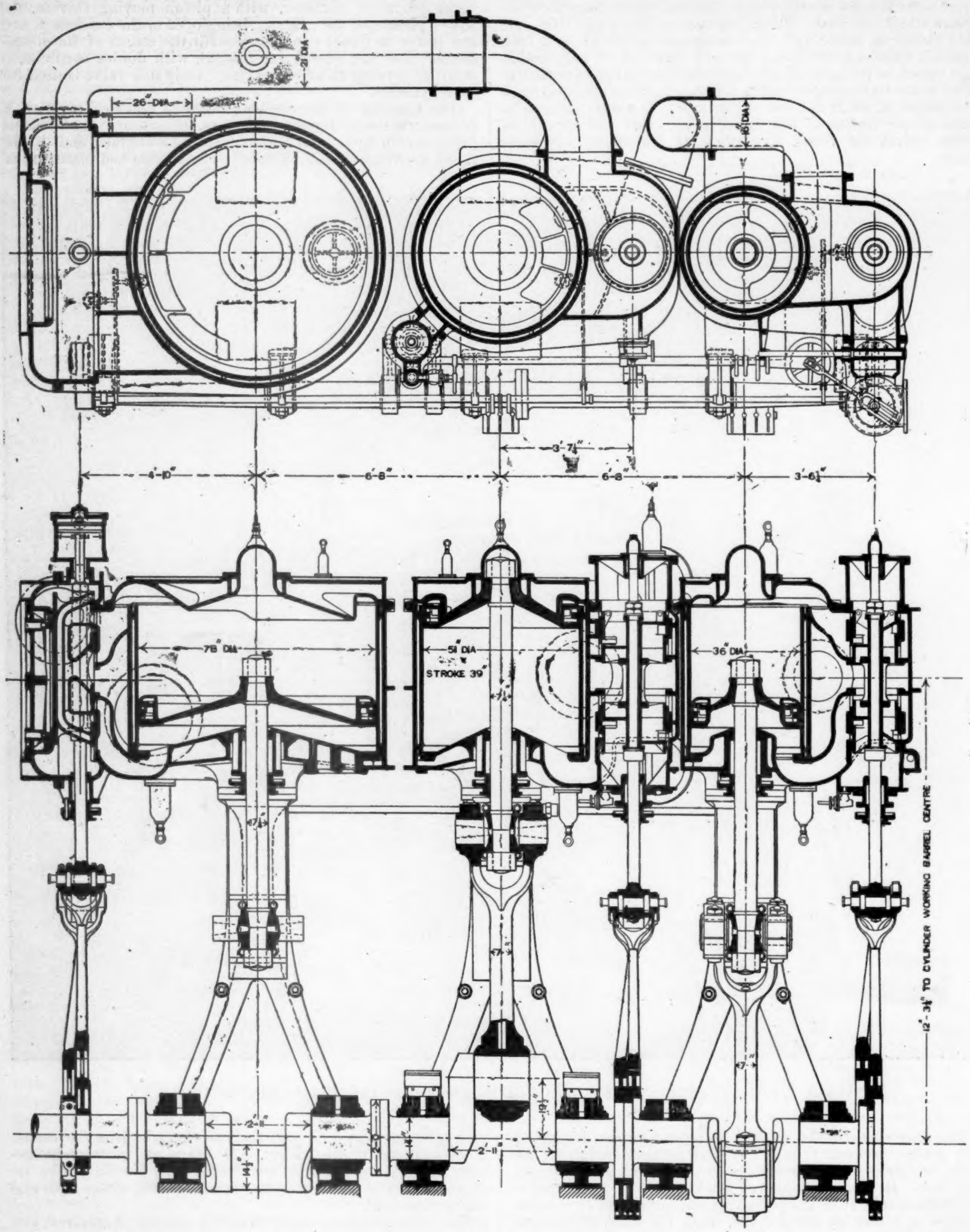
ENGINES U. S. BATTLE-SHIP "TEXAS," BUILT BY RICHMOND LOCOMOTIVE WORKS, RICHMOND, VA.

The engines are of the vertical inverted cylinder, direct-acting, triple-expansion type. The high-pressure cylinders are 36 in. in diameter, the intermediate, 51 in., and the low-pressure, 78 in., all having a common stroke of 39 in. The collective indicated H.P. of the propelling, air pump and circulating engines is placed at about 8,600, when the main engines are making 123 revolutions per minute.

A reference to our engraving, giving a longitudinal section through the engines, shows that all the cylinders are steam jacketed. They are so placed that the high-pressure cylinder of each engine is forward and the low-pressure cylinder is aft. Piston valves are used for the main valves of the high-pressure and the intermediate cylinders, while a double-ported balanced slide valve is used for the low-pressure cylinder, details of these valves being given in separate engravings. It was found on trial that the weight of the low-pressure valve was so great that the eccentrics heated, and the valve was so difficult to move that a balancing cylinder with piston, as shown in the engraving, was placed over the steam chest to carry the weight of the valve and the reciprocating parts. This is a simple cylinder 15 in. in diameter, with a piston moving therein, the upper portion of the cylinder being open to the condenser, and the lower in direct connection with the steam of the steam-chest. The Stephenson link motion, with double bar links, is used for driving all of the valves. Only one valve is used for each cylinder.

The framing of the engine consists of cast-steel inverted Y frames, trussed by forged steel stays, the appearance and shape being shown by a reproduction of the photograph and the detailed drawings of the engines. The engine bed plates are of cast steel supported on steel keelson plates built in the vessel. The crank shafts are hollow, and are made in interchangeable sections, open-hearth steel being used for all of the reciprocating and working parts, such as shafts, piston-rods and connecting-rods.

The cylinders are made from a high quality of cast iron, and have a working lining of cast steel which is shown on the engraving. The valve chests with the steam ports and passages, the bottom heads, and various brackets to which the cylinder supports and gears are attached, are cast solid with the cylinders themselves, great care being taken that the exhaust ports were smoothly cored and the walls of the passages strongly stayed with ribs. The cylinders are secured together by two steel braces $2\frac{1}{4}$ in. in diameter secured to flanges cast in the proper position. The cylinder heads of the high-press-

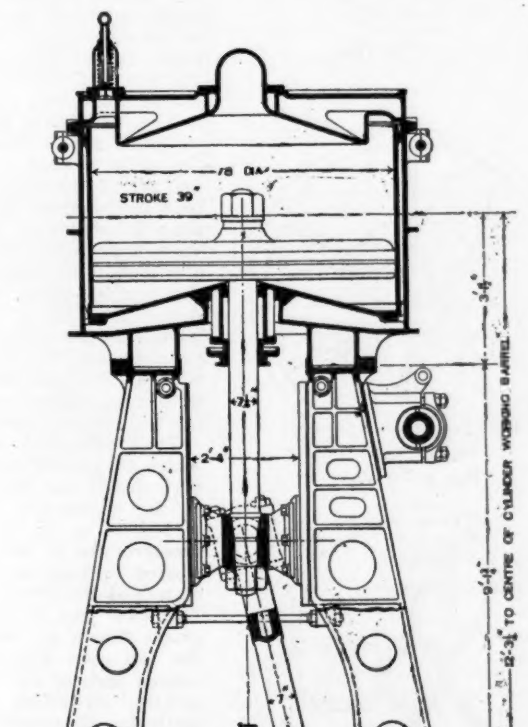


MAIN ENGINES OF THE U. S. BATTLE-SHIP "TEXAS," BUILT BY THE RICHMOND LOCOMOTIVE WORKS.

ure cylinders are cast with double walls and the shells are $1\frac{1}{4}$ in. thick. They are placed and bored for the reception of the cylinder linings, the valve-chest casings being also bored to a diameter of 15 in. for the reception of the piston valves.

The bottom indicator pipe is fitted with a brass bushing which extends through the cylinder lining and casing. The intermediate and low-pressure cylinders are constructed in practically the same way, the thickness of the shell being the same for all three cylinders. The principal difference in them being that, in the bottom head of the low-pressure cylinder there is a man-hole 15 in. in diameter, which is fitted with a cast-iron cover which is also cast double and well strengthened with ribs.

The cylinder linings, to which reference has already been made, are made of cast steel carefully turned to fit the cylinder casings and guide ribs. They have inward flanges at the bottom and are secured by countersunk, slotted, cheese headed, Muntz-metal screws tapped into the cylinder shells. The joint at the upper end of each lever is made tight with a collar for expansion pipe, and a ring of round copper $\frac{5}{8}$ in. in diameter forced into the packing space. This copper ring is held in position by a wrought-iron ring $\frac{3}{4}$ in. wide and $\frac{1}{2}$ in. thick, secured to the cylinder liner by $\frac{1}{2}$ in. wrought-iron square-headed tap bolts. These liners are bored to the cylinder diameters—namely, 36 in., 51 in. and 78 in.—after being placed in position, and have a uniform thickness of $1\frac{1}{8}$ in. for all the cylinders. Care was taken to bore these while the cylinders were in a vertical position, so as to prevent all springing due to the weight of the metal, so the boring was done in the working position of the cylinders. The linings are so counterbored at



ENGINE U. S. BATTLE-SHIP "TEXAS." SECTION THROUGH LOW-PRESSURE CYLINDER.

the bottom that the working bores have a length of $44\frac{1}{2}$ in. The cylinder heads are of the same quality of cast iron as the cylinders themselves, and are cast with double walls except at those points where they form a portion of the steam passages. The walls of these heads are well stiffened by ribs of the same thickness as the walls themselves, which is 1 in., and each head is provided with a 16-in. man-hole.

The steam jacket drains are fitted with an internal pipe leading to the lowest part of the heads, and each head is secured to its cylinder by forty $1\frac{1}{4}$ in. steel studs. The man-hole covers for the cylinder-heads are of cast steel, made of a dish form, so as to clear the piston-rod nuts, and are secured by $\frac{7}{8}$-in. steel studs. The cylinders are steam jacketed on the top, sides and bottoms, the space left about the working linings for the steam jackets being not less than 1 in. in depth at any point. The steam for the jackets is taken from the main steam pipe in each engine room on the boiler side of the engine stop valve by a 2-in. pipe. From this pipe a 1-in branch leads to the high-pressure cylinder-head jacket, which drains through a 1-in. pipe leading from the lowest part of the head, and connects with the upper part of the barrel jacket. A $1\frac{1}{4}$-in. branch with a $1\frac{1}{4}$-in. adjustable spring reducing valve, adapted to pressure of from 20 lbs. to 100 lbs., leads to the intermediate pressure cylinder-head jacket, and another with a similar reducing valve, ranging from 0 lbs. to 50 lbs., leads to the low-pressure cylinder-head jacket. Each branch pipe is further provided with a stop valve close to the jacket itself. Safety valves $1\frac{1}{2}$ in. in diameter are placed on the intermediate and low-pressure jackets, and are of the same design as the receiver safety valves. These receiver safety valves, which are placed on the intermediate and low-pressure receivers, are 3 in. in diameter, and are loaded from 80 lbs. to 25 lbs. respectively for the intermediate and low-pressure receivers.

The valve chests of each high and intermediate cylinder is fitted with a piston valve similar in design to the intermediate valve, a detail of which is shown. There are openings at the top of the high and intermediate chests for inserting and removing the valves, and the chests are accurately bored to the same diameter as these. The low-pressure valve chest, which contains a double-ported slide valve, has an opening on the side for the purpose of removing this valve. The intermediate and low-pressure valve chests also have, in addition to the safety valve on the receivers, 3 in. adjustable spring safety valves, which are loaded to 80 lbs. and 25 lbs. respectively.

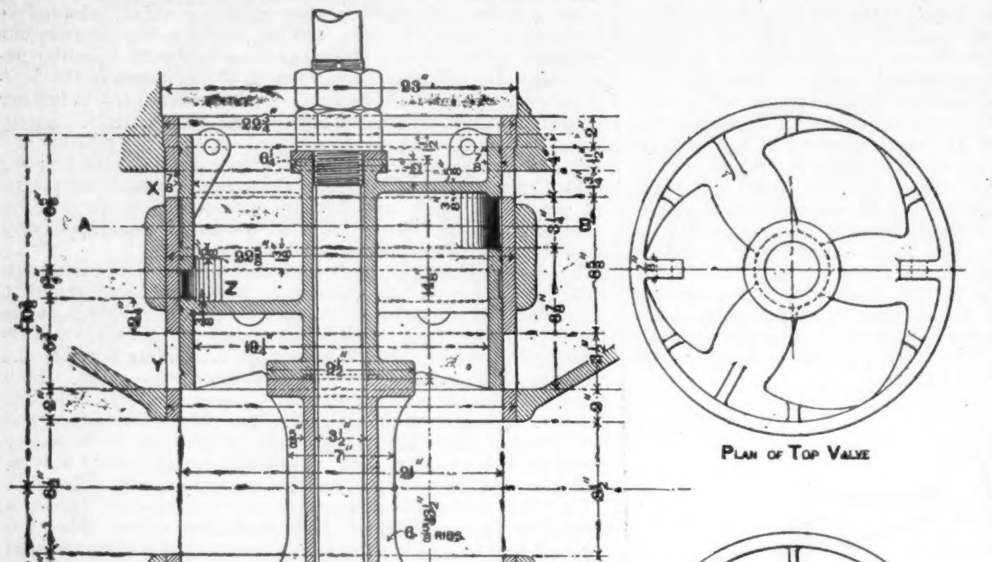
The design of the high-pressure and intermediate valves is shown by the engraving of the intermediate valve. They are made of cast iron as hard as can be properly worked and fitted accurately in the valve casings, no packing rings being used. The metal of their walls is $\frac{3}{4}$ in. thick. Each valve consists of two hollow pistons and a distance piece which has two flanges for securing the pistons the proper distance apart. Each distance piece has six ribs $\frac{7}{8}$ in. thick. The valves are accurately turned to fit the valve chest cases to a diameter of 15 in. and 21 in. respectively for the high-pressure and intermediate cylinders. There are five semicircular grooves on the surface of the valves at each end $\frac{1}{8}$ in. deep for water packing. There are also two lugs on the upper portion of the valve bored with 1-in. holes for convenience in handling. The two parts of each valve are separated when in place on their vertical stem by cast-iron distance pieces which are of such length as to make the steam lead and lap as follows: High-pressure steam lead, top, $\frac{1}{4}$ in.; bottom, $\frac{15}{16}$ in.; high-pressure steam lap, top, $2\frac{1}{4}$ in.; bottom, $2\frac{3}{16}$ in. The steam lead of the intermediate cylinder is $\frac{1}{4}$ in. at the top and $\frac{15}{16}$ at the bottom; the steam lap of the same cylinders is $2\frac{1}{4}$ in. at the top and $2\frac{3}{16}$ in. at the bottom.

The area of opening of the intermediate valves is calculated at 205 sq. in., which leaves an opening of $3\frac{1}{8}$ in. at the top and $3\frac{9}{16}$ in. for the bottom. When the engine is running at 123 revolutions per minute the flow of steam through the opening of the intermediate cylinder is 132.7 ft. per second, with an exhaust speed of 94.18 ft. An examination of the drawings and valves of this intermediate cylinder will show that the arrangement of the steam passages is of a somewhat complicated nature, but by referring the various sections to the points in which they are taken a clear understanding of the movement and distribution of the steam will be readily attained.

The drawing of the high-pressure valve, which is not reproduced here on account of its being exactly similar in design to the intermediate valve, shows that the area of the openings is calculated at 144 sq. in., which leaves an opening of $3\frac{1}{8}$ in. at the top and $3\frac{9}{16}$ in. for the bottom of the valve, the same as in the intermediate cylinder. When the engine is running at standard speed as before the flow of steam through the openings of the high-pressure valve is 92.9 ft. per second, while the exhaust is 67 ft. per second. The calculations for the low-pressure valve give an area of 374 sq. in., with an opening of $5\frac{1}{8}$ in. at the top and $5\frac{3}{16}$ in. at the bottom. With the engine at nominal speed the flow of steam is 168 ft. per second, while the rate of flow of the exhaust is 165.8 ft. per second.

The engraving, showing a vertical section through the intermediate steam-chest, with a valve in the central position, can be used to illustrate the action of the steam. Taking the cross section of the valve that is shown immediately below the vertical section of chest, and which is taken on the line *A B*. If

the valve moves down the passage *Z*, which is in communication with the top of the valve, opens into the passage *Y* at the same time that the top end of the valve opens the passage *X*, thus giving a double-ported opening into the steam passages to the cylinder. The valve being made line and line on the inside, the moment it passes the central line on its downward stroke the passage *U* is opened to the exhaust direct, and the passage *V* is also open by way of the port *W*, which is shown in dotted line. This valve is so arranged that the three steam ports have an area of 50 sq. in. each, giving a total of 150 sq. in. The three exhaust ports have an area of 18.5 sq. in. each, giving a total of 55.5 sq. in. The size and thicknesses of metal



ENGINES U. S. BATTLE-SHIP "TEXAS." VALVE FOR INTERMEDIATE CYLINDER.

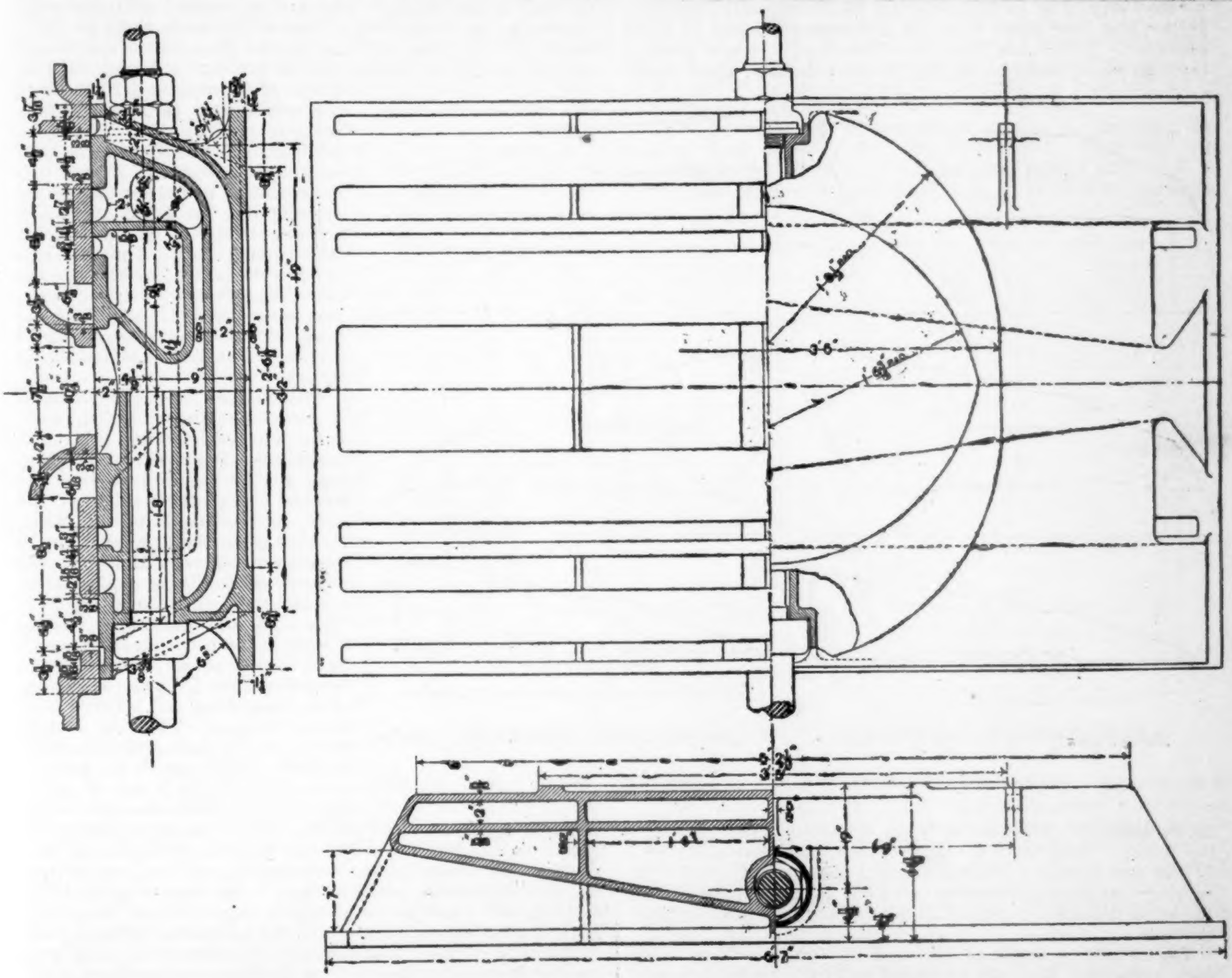
of the valves in cross section is given on the large detailed sketch of the valve of section on *C D*. The low-pressure slide valve is double ported as shown, and is made of cast iron thoroughly strengthened by ribs. There is a passage through the valves, so that the exhaust steam may be used to cushion the pistons and give a quick port opening at the commencement of the stroke. The face and back of each valve is carefully finished to true planes, and a balanced plate worked on the back of each valve. The dimensions of the valve are such that the steam lead at the top is $\frac{1}{4}$ in. and $\frac{5}{16}$ in. at the bottom. The steam lap at the top is $2\frac{1}{4}$ in. and $2\frac{5}{16}$ in. at the bottom. There is a cast-iron relief ring, 41 in. in diameter, fitted to the back of this valve to take off the pressure on the back. This relief ring is turned and faced to fit the composition bushing in the valve chest cover and back of the valve, a copper expansion ring being bolted to the relief ring and flange of the interior sleeve. The relief ring is held against the back of the valve by composition studs on a spiral round steel spring fitted in interior sleeves cast on the bonnet. These springs are made of $\frac{3}{8}$-in. round steel, the tension being regulated by wrought-iron set screws passing through composition taps screwed into the sleeves. The outside of the opening is covered with a brass plate $\frac{1}{16}$ in. thick, so as to make a smooth finish. A comparison of the longitudinal and cross sections of the valve will show that the interior and double ports are so cored out that there is a double-ported opening for the exhaust and a triple opening for steam admission. The triple opening for the steam admission is accomplished by the admission of steam at the end of the valve through the Allen port and through the central part which is cored out next the exhaust passage, and to which admission is gained from the side of the valve, as shown on the cross section. The method by which the double ported opening is obtained for the exhaust is clearly shown on the engraving. The inside lap of the slide valve is placed at $1\frac{5}{8}$ in. At the same time, there is a negative lap of $\frac{3}{8}$ in. of the Allen port, allowing steam to pass from one end of the cylinder over to the other before the exhaust opens. The valve stems are of forged steel 4 in. in diameter at the stuffing-boxes, reduced to 3 in. at the valves, the lower end of the stem being provided with a club end fitted with composition bushing and cap and bolts.

The indicator cards which we publish show very clearly the action of the engine and the variations in the back pressures due to the increased opening at the bottom of the cylinder. The two sets of diagrams shown are from the top ends and the bottom ends of the respective cylinders, as marked. The combination card is taken from the starboard engines and really explains itself. The top cards are taken from all the cylinders, with a uniform cut-off of $27\frac{3}{4}$ in., and give the following results: The mean effective pressure in the high-pressure cylinder was 53.04 lbs.; that in the intermediate cylinder was 33.50 lbs.; that in the low-pressure cylinder was 16.80 lbs. This was when the engine was running at 90 revolutions per minute. The resultant indicated H.P. was 478.52 for the high-pressure, 606.58 for the intermediate pressure and 711.54 for the low-pressure, giving a total indicated H.P. top and bottom of 3,591.49. This varies somewhat from what was the total of the indicated H.P. just given in detail, which was taken from the top cards exclusively, being a little less owing to the lower mean effective pressure in the bottom ends of the cylinders. Doubling this H.P. as given we get 7,183 H.P. for the total indicated H.P. of the two propelling engines.

Each end of each main cylinder is provided with a cylinder relief valve, the diameter of those for the high-pressure and intermediate cylinder being 3 in. and that of the low-pressure cylinder 4 in., the load being placed at 155 lbs. for the high pressure, 80 lbs. for the intermediate and 25 lbs. for the low pressure. Each cylinder is also fitted for 1½-in. drain cocks. All of the drain cocks of each engine discharge into a pipe leading from the fresh water side of the condenser with a branch to the bilge. This pipe has a stop valve near the condenser and has a spring check valve with hand gear which can open to the bilge discharge when the drain to the condenser is closed, but it will prevent air from entering the condenser at any time. The stop and throttle valve of the engine are in one casing, the former being 11¾ in. in diameter. The composition of the casing, as prescribed by the specifications, is 87 per cent. copper, 8 per cent. tin and 5 per cent. zinc. The casing of the intermediate valve is provided with a starting

white-metal wedge-shaped rings and three or more turns of Tuck's packing.

The connecting-rods with their caps and bolts are of forged steel finished all over. They are 78 in. long between centers, and are turned 7 in. in diameter at the small and 7½ in. at the large end. There is a central 3-in. hole extending from end to end. The cross-head end is forked to span the cross-head, each of these forked ends being 6½ in. thick, faced on each side and fitted with caps bored to a diameter of 9½ in. for the brasses. These caps are 3½ in. thick at the crown, the bolts being 3 in. in diameter over the threads, reduced to 2 11/16 in. diameter for a space of 3½ in. near the head and nut. The nuts are of forged steel, each having a collar recessed into the cap and secured by a set screw and split pin at the ends of the cap bolts. At the crank-pin end each connecting-rod is increased in thickness to 13½ in., and is bored to 18½ in. in diameter for the brasses. The caps are 4½ in. thick at the crown, each con-



ENGINES U. S. BATTLE-SHIP "TEXAS." VALVE FOR LOW-PRESSURE CYLINDER.

valve, the seat and valve being of composition metal, while the chest and cover is of cast iron.

The piston-rod stuffing-boxes are of cast iron, the high pressure being cast with the cylinder casing and the intermediate and low-pressure one separate. The upper surface of the stuffing-box has a recess of 1 in. in depth and 8¾ in. in diameter for the collar on the piston-rod, as shown on the longitudinal section of the intermediate and low-pressure cylinders. The glands are of cast iron recessed on the upper surface of the flange ¾ in. deep for the oil box. These glands are set up by four 1½-in. studs fitted with pinion nuts and a spur ring having a composition keeper made in halves and secured in position by four ⅝-in. studs, holding the teeth on the pinion nuts and spur ring in gear. On the inside of the gland bushing there is a groove ⅛ in. deep and 1 in. long turned and connected by a ⅜-in. hole with the oil groove on the upper surface of the flange of the gland. Metallic packing is used for each stuffing-box. This consists of four composition and four

forming to the shape of the connecting-rod end. The bolts are 4 in. in diameter and have heads fitted with stop pins. The nuts are also of forged steel at this point. The oil hole is drilled at the lower end of each connecting-rod for the crank-pin oil pipe. The pistons are of cast steel slotted in dish form, as shown in the engravings, with a boss 10½ in. in diameter at the center for the piston-rod, with a flange and recess at the periphery for the springs, packing ring and follower. The followers are made of cast iron, with recesses for bolts. Composition bushings are screwed into the pistons and secured by ½-in. screw pins tapped for the follower bolts, these latter being of steel 1¼ in. in diameter, with square heads and set up on brass washers 3/16 in. thick. The high-pressure piston is provided with nine follower bolts. There are 14 in the intermediate and 24 for the low pressure. There is also a recess turned on the boss 2 in. long and ½ in. deep with drawing gear. Each piston has one cast-iron packing ring 1½ in. thick and 6 in. wide, cut obliquely and fitted with a composition

tongue. These rings are set out by semi-elliptical steel springs each 9⅞ in. long, 5½ in. wide and $\frac{3}{16}$ in. thick at the center, tapered down to ¼ in. at the ends. The holes for the piston-rods taper from 7¼ in. to 5¾ in. in diameter.

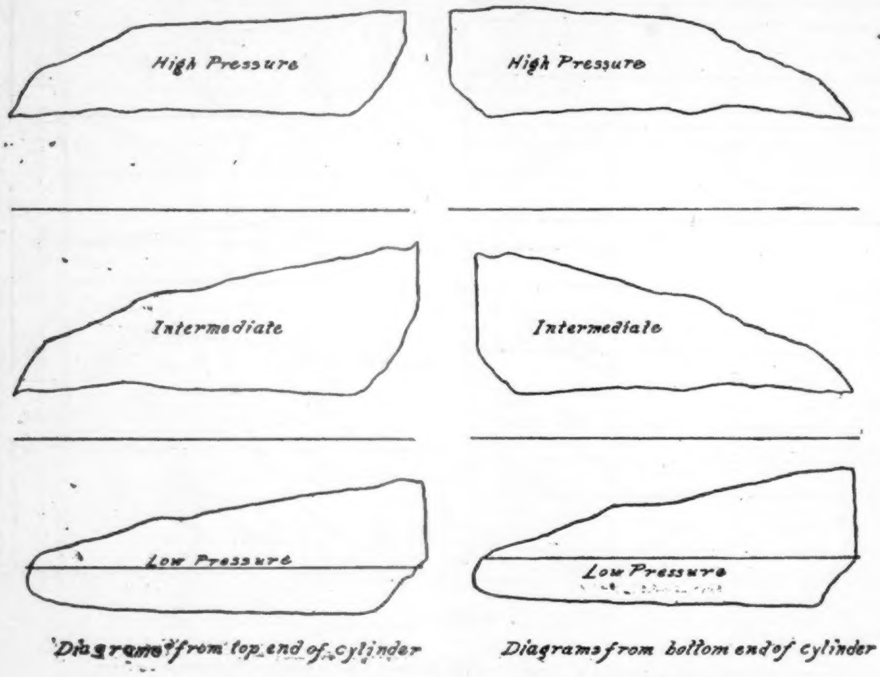
The cross-heads are of cast steel with faces 18¼ in. long and 19 in. wide, arranged to receive composition gibs. The pins are cast solid with the head, are 8 in. in diameter and 9½ in. long for each crank-pin brass.

As has already been said, the cylinders are carried by inverted Y cast-steel columns. These columns are of I section, well ribbed, and have lightening holes in the vertical web at such points where they could be placed. They have flanges at the top and bottom that are planed off to fit the brackets on the cylinders. These columns are secured to the brackets by eight 1⅞-in. body-bound bolts of forged steel for each flange, and to the engine bed by six 1½-in. body-bound bolts of the same material.

There are two lugs on each frame bored for athwartship for steel stays 2 in. in diameter, that tie the opposite frames together, also one bored face for a fore-and-aft stay 2½ in. in diameter. There are also two fore-and-aft stays passing through faced bosses at the top of the columns; these are 2½ in. in diameter, increased to 2¾ in. where they pass through the bosses. These stays are made in two parts, connected by a 3$\frac{11}{16}$-in. turn-buckle. There are also two athwartship stays connecting supporting columns of each cylinder. These are 1$\frac{11}{16}$ in. in diameter, increased to 2 in. where they pass through the boss.

The cylinder stays consist of two 2½-in. fore-and-aft stays for each cylinder. They are increased to 2⅞ in. where they pass through the faced brackets on the cylinder casings. The bed plates consist of steel castings of I section, the upper and lower flanges being connected to the web and stiffened by ribs, the engine seating being secured to the same by 1¼ in. body-bound forged steel bolts.

The brasses for the crank shaft and caps are made in two parts, each 1½ in. thick, lined with white metal that is dovetailed and hammered in place, and then fitted with ample oil channels. They are 16¾ in. long. Each cap and upper brass is provided with an oval hand-hole for the purpose of feeling the journal. This hand-hole has a cover with a handle, the lower part of the frame being formed into an Allen box, with perforated holes reaching to within ¼ in. of the journal. The cap bolts are of forged steel 3¾ in. in diameter and each provided with a collar. The go-ahead guides are of cast iron 2 in. thick recessed on the back ½ in. deep to correspond with the recess in the supporting columns for the water service. They are secured by twelve 1¼-in. counter-sunk, cheese-headed bolts. The wearing surface of these guides has a length of 55 in. and a width of 19 in. At the bottom there are two 1-in. holes fitted with composition nipples for the inlet and outlet of the circulating water. The eccentrics are of cast steel, the high-pressure eccentrics being formed in one casing, but those of the intermediate and low-pressure cylinders are separate and in two parts. The high-pressure and intermediate eccentrics have a width of 4½ in., while those for the low-pressure cylinder are 4¾ in. wide with a recess on each side of ⅝ in. in width and ⅜ in. in depth for the flanges of the eccentric straps. These latter are of cast steel of I section and faced with composition, and are provided with lugs for the heads of the eccentric-rods and the eccentric-bolts. They have a recess at each edge ½ in. wide and ⅜ in. deep for the composition lining, which is secured to the strap by ½-in. countersunk tap screws. The two parts of the straps are held together by forged steel bolts 2 in. in diameter. They are provided with composition distance pieces fitted with thin liners. The eccentric-rods are of forged steel finished all over, having heads, and are secured to their eccentric straps by two steel stud-bolts 2 in. in diameter. The upper end of each rod is forked to span the link in the ordinary way, and is provided with the usual brass caps and bolts. The bars of the main links are 1¾ in. thick and 5 in. wide, with the pins for the eccentric-rods forged on, and finished to a diameter of 3 in. and a length of 3½ in. These pins are spaced 20 in. from center to center, each pair of bars being secured by three bolts 1½ in. in diameter. The reversing gear of each engine consists of a steam cylinder and a hydraulic controlling cylinder that are placed vertically and act directly on an arm fixed on the reversing shaft. The steam cylinder is 12 in. in diameter and the controlling cylinder 6 in., the common stroke being 17½ in. They are made of cast iron, and are placed vertically, the steam cylinder being on top.



INDICATOR CARDS OF THE U. S. BATTLE-SHIP "TEXAS."

The valve of the steam cylinder is of the piston pattern, made of composition metal working in a composition-lined valve chest. The by-pass on the hydraulic cylinder is worked by a continuation of the stem of the steam piston valve, these valves being worked by a system of differential levers, the primary motion being applied from a hand lever on the working platform and the secondary motion from a pin on the reversing arm, all parts being so adjusted that the reversing lever follows the motion of the hand lever and is firmly held when stopped. There is a stop-cock in the by-pass of the hydraulic cylinder, and a pump is attached for reversing by hand in case of necessity, with its lever convenient to the working platform. The piston of the hydraulic cylinder engine is packed by two, and the stuffing-box by one cup leather packing, the steam for the reversing engine being taken from the auxiliary steam pipe. There is one reversing shaft for each engine, made in two lengths with flanged couplings. Each shaft is of forged steel like the remaining working parts of the main engine. The exhaust pipes consist of a 16-in. pipe leading from the exhaust side of the high-pressure valve-chest, with a 16-in. branch to each end of the flanges of the corresponding intermediate cylinder. A 21-in. pipe fitted with a slip joint leads from the exhaust side of the intermediate flanges to the corresponding low-pressure flanges, and a 26-in. pipe leads from each low-pressure flange to the corresponding condenser, each pipe being fitted with a slip joint where it joins the condenser. There is a 6-in. nozzle on the exhaust pipe connecting the intermediate and low pressure for the auxiliary exhaust. The pipes are made of composition and copper.

The working platforms are located on the inboard side of each main engine between the high and intermediate-pressure cylinders. Here the revolution indicators, clock, gauges, telegraph dials and other engine-room fittings are so placed as to be in full view while working the engines. The working levers and gear on each working platform consist of one reversing lever, one starting valve lever, one lock and throttle-valve lever for reversing engines, three cylinder drain cock levers, hand levers, pump lever, stop-valve, hand-wheel, throttle-valve lever, starting valve and the stop-valve hand-wheel. The drain cock levers have spring catches, while the others have spring catches of the locomotive pattern.

All of the crank, line, thrust and propeller shafts are of steel, each length being forged solid in one piece with a hole drilled axially through it from end to end. All shafts are finished all over, and the taper holes for the coupling bolts are so drilled that the bolts drive from the forward.

The crank shafts are made in three sections for each propelling engine, and they are all alike and interchangeable. Each section has a crank of 19½ in. throw, with a coupling disk about 3 in. thick and 24 in. in diameter forged on each end. The length of each section of the shaft is 6 ft. 8 in. over all, with two journals on each end of the same, each 14 in. in diameter and 19½ in. long. The crank pins are 14½ in. in diameter and 8 in. long. The webs are 15 in. wide and 8½ in. thick, and bevelled off as shown in the longitudinal section of the engine. A 6-in. hole is bored axially through each shaft and a 7-in. hole through each crank-pin. When bolted together the cranks stand at an angle of 120° to each other, the low-pressure following the high-pressure, and the intermediate following the low pressure on the forward motion. Taper bolts 2⅞ in. in mean diameter are used to couple the various lengths of crank shafts together. There are nine bolts in each coupling, all holes being drilled and ribbed to a template, so that the couplings will match indiscriminately. The thrust shafts are 13½ in. in diameter, 19 ft. 7½ in. over all and bored with 6 in. axial holes. Each shaft is provided with eight thrust collars 2 in. thick, with spaces of 3½ in., the collars being 23 in. outside diameter. On the forward and after ends coupling disks 3 in. thick and 24 in. in diameter are forged. The line shafts are each 13½ in. in diameter and 19 ft. 8 in. over all, with a 6-in. axial hole bored from the forward end to 15½ in. from the after end. The coupling disk, 3 in. thick and 24 in. in diameter, is forged at the forward end. At the after end of the shaft for a distance of 19 in. the shaft is enlarged to a diameter of 19½ in., with a coupled flange 3 in. thick and 22½ in. in diameter. The enlarged portion of each shaft has an axial hole 15⅝ in. long, tapering from a diameter of 13½ in. at the after end to 12½ in. at the forward end, where it joins the 6 in. axial hole. On the inner circumference on the taper hole there are two keyways cut diametrically opposite each other, each keyway being ⅞ in. deep and 2½ in. wide. The propeller shafts are in two lengths, the forward length being 14⅝ in. in diameter and 25 ft. 3 in. long over all, while the after length is 14 in. in diameter and 30 ft. 4½ in. over all. A 6-in. axial hole is bored through the forward section of each shaft. This section is also provided with a composition casing made in three sections, which extends from 4½ in. off of the forward flange coupling to 3 ft. 4½ in. forward of the after end. This casing is shrunk and pinned on and is water-tight. The forward section of the casting is 4 ft. 9 in. long and 1⅛ in. thick. The middle section is 1 in. longer and ½ in. thick, while the after section is 5 ft. 3 in. long and ⅝ in. thick. The joints lap over each other by 1 in. and are burned together. The forward and after ends of the casings are tapered for a distance of 3 in., the after end being protected by a fillet of soft solder. The forward end of the forward length of the propeller shaft is tapered to fit the taper end of the line shaft. The after section of the propeller shaft also has a 6-in. axial hole down to the point where the shaft is tapered for the propeller hub; here it is reduced to 3 in. in diameter. The after section is incased in composition ⅝ in. thick where it passes through the outboard bearing, the casing being of one length shrunk and pinned on, protected at the forward end by a fillet of soft solder and the after end being a water-tight joint with the propeller hub. The after end is, of course, fitted to the bore of the propeller shaft, and is provided with one feather key. Abaft of this the diameter is reduced to 10½ in. The propeller is secured by a cast-steel nut recessed on the face and fitted with an india-rubber ring, making a water-tight joint between the nut and the hub.

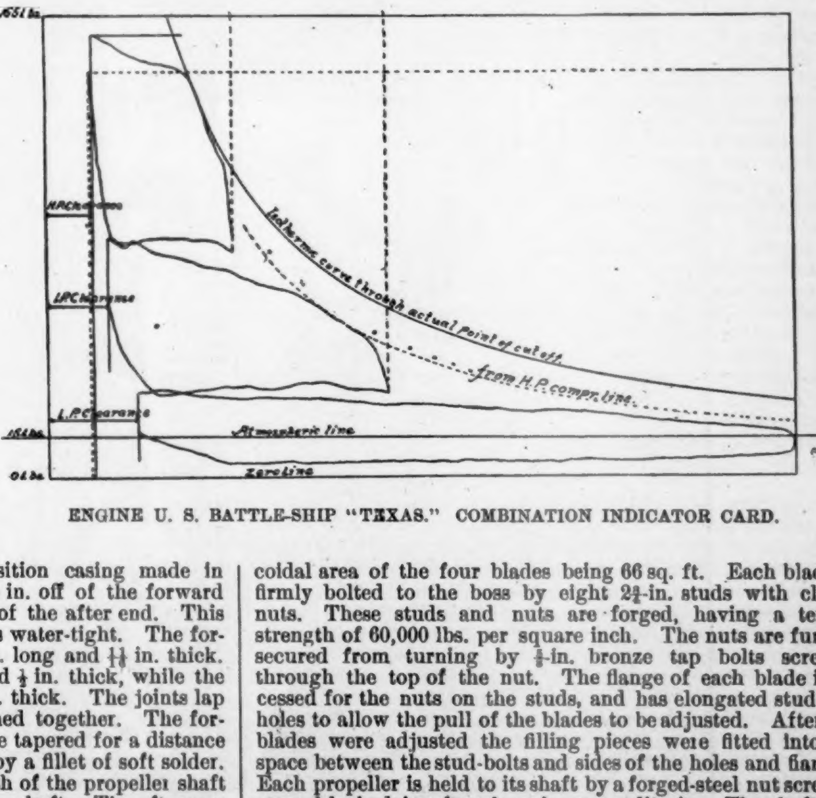
Stuffing-boxes are provided for all shafts at the points where they pass through the water-tight bulkheads. These are made of cast iron in halves, divided horizontally, and bolted together by four ⅞-in. bolts.

All parts of the machinery are oiled by closed oil-boxes, the details of which are so arranged as to be adapted to the peculiarities of this engine. They include direct leading tubes and wipers.

The thrust bearings are of cast iron with walls 1½ in. thick, and there are seven adjustable cast-steel horseshoe thrust rings 2½ in. thick, faced on each side with white metal ½ in. thick, dovetailed, hammered into place and provided with oil grooves. These thrust rings are adjusted by forged steel nuts 1½ in. thick, so that each ring takes its share of the thrust. At each end of the thrust bearing there is a cast-iron bearing 15 in. long to take the weight of the shaft. Each stern tube bearing is provided with a composition lining turned to fit the tube, which is inserted from the inboard end and secured with a water-tight flange joint. This lining has an outside diameter of 19⅝ in. at the inboard end, and 19½ in. at the outboard end, with a diameter of 8 in. in the center between the bearings. The inside diameter of the lining is 16⅝ in., while the taper length of the same from the face of the inboard flange to the after end is 18 ft. 1 in. This is counterbored at each end, and each counterbore is fitted with strips of lignum vitæ fitted so as to bear on end of the grain, and smoothly and accurately bored to the diameter of the shaft casing after being secured into position. The lignum vitæ at the forward end extends 36 in. from the after end of the counterbore, and is prevented from turning by two composition strips at each end of the lining.

The propellers are of manganese bronze, the starboard one being right and the port one left-handed. They are four bladed, each 14 ft. 6 in. in diameter, cast with a pitch of 17 ft. 4 in., and adjustable from 16 ft. 6 in. to 18 ft. 3 in., the helicoidal area of the four blades being 66 sq. ft. Each blade is firmly bolted to the boss by eight 2⅝-in. studs with closed nuts. These studs and nuts are forged, having a tensile strength of 60,000 lbs. per square inch. The nuts are further secured from turning by ⅝-in. bronze tap bolts screwed through the top of the nut. The flange of each blade is recessed for the nuts on the studs, and has elongated stud-bolt holes to allow the pull of the blades to be adjusted. After the blades were adjusted the filling pieces were fitted into the space between the stud-bolts and sides of the holes and flanges. Each propeller is held to its shaft by a forged-steel nut screwed on and locked in place by a bronze split-pin. The shaft casing enters about ⅞ in. into the propeller, and is fitted water-tight by means of a rubber ring. Each boss is further finished at the after end by a composition cap bolted on water-tight, the bosses and caps being finished all over. In addition to the main engines there are turning engines and gear in each engine-room. This consists of a single engine for turning the main engines, which works under a steam pressure of 150 lbs. The cylinder of this engine is 4½ in. in diameter and 6 in. stroke; it drives by a worm gearing a second worm which meshes in with the worm wheel on the propeller shaft, the worm wheel of each engine being fitted on the flange coupling at the after end of the crank shaft. Piston valves are also used on these turning engines, and they are made reversible by means of a change valve moved by a screw and hand-wheel. The turning wheels are of cast steel with cut teeth, and the shafts and worms are of forged steel.

It is, of course, unnecessary to recapitulate the gauges and valves which are used on the boilers and engines for indicating steam pressure, vacuum, height of water, etc. Thermometers



ENGINE U. S. BATTLE-SHIP "TEXAS." COMBINATION INDICATOR CARD.

EXPRESS PASSENGER ENGINE FOR THE MIDLAND RAILWAY.

are placed at all points where it is necessary that the temperature of the water should be known, and revolution counters of the continuous rotary type are added to register from 1 to 1,000,000. In addition to this there are revolution counters which specifications demand should not be influenced by changes in the temperature, the vibration of the engines, or the motion of the vessel. Tell-tales are fitted on the bridge and in the conning-tower to show the direction of the revolution of the main engines, and in addition to this there is a repeating telegraph connecting the dials on the working platform with those of the conning-tower, wheel-house and bridge. Speaking-tubes connect each engine-room with each fire-room and with each other, the fire-rooms with each other, and each engine-room with the pilot-house, conning-tower, bridge and chief engineer's room. Each fire-room is also connected with the upper deck close to the top of the ash-hoist. Engine indicator connections are made at the usual points.

The engine-rooms are ventilated by means of exhaust fans, each 4 ft. 6 in. in diameter, driven by a vertical direct-acting engine having a steam cylinder 6 in. in diameter and 4-in. stroke. The air ducts that lead from these fans are provided with adjustable openings so arranged as to thoroughly ventilate all parts of the engine-room and shaft alleys, the air being discharged through ducts leading to the spar deck. Every arrangement is made for the comfort and convenience of handling and working the engines as far as the limited space will allow ; but it must be remembered that in a vessel of this type, with a large H.P. to be developed, and the immense amount of machinery contained within such a small space, that every inch of room is valuable and the machinery is crowded together most compactly. Attention was particularly called to this matter when, in our issue for May, we described the feed pumps for the same vessel. Contracts for the main engines and all machinery used here described was taken and filled by the Richmond Locomotive Works, of Richmond, Va., the engines being designed at the Navy Department with the exception of a few variations which were added at the works. In a future issue we expect to describe still further some special appliances which are used in the engineers' department of this vessel.

EXPRESS PASSENGER ENGINE FOR THE MIDLAND RAILWAY.

The Dore and Chinley section of the Midland Railway has recently been opened, and this establishes a new express route between Liverpool and Manchester and Sheffield. The line passes over the peak district of Derbyshire on gradients that are very severe throughout.

The engine which we illustrate is one of the type of 20 which have been built for this special service. Fifteen of them have been built by Sharp, Stewart & Company and five by the Midland Company. The diameters of the cylinders are 18½ in. with a stroke of 26 in. The driving-wheels are 6 ft. 6 in. in diameter, and the boiler carries a pressure of 160 lbs. per square inch. The capacity of the tenders is 3,250 galls. of water.

The standard size of driving-wheels for the Midland engines is 7 ft., but these have been made 6 in. smaller on account of the gradients.

RACK RAILWAYS.

It often happens that old ideas or inventions patented many years ago, which seem to have sunk into oblivion, are half a century later revived under a new form, and become valuable acquisitions to the industrial and scientific world. Such has been the case with rack railways. The first rack railway was built in 1811 near Leeds, by Blenkinsop. It was a mistaken conception, if you like, but in it was, nevertheless, the germ of the invention which has made mountainous districts accessible by rail to tourists, and in many cases connected them with main lines. The engineers of the early part of the century were under the impression that the adhesion between the ordinary plain wheel and rail would not be sufficient to effect the propulsion of the locomotive then in its infancy. Blackett, in 1811, showed that toothed wheels and racks were needless for this purpose. Fifty-nine years were to elapse before Sylvester Marsh in the United States, and Riggenbach in Switzerland, were to revive the idea and assign it its proper place and use—namely, in those heavy gradient railways where the adhesion of the ordinary locomotive rendered it entirely inadequate to haul any load worth mentioning besides itself.

The Mount Washington Railway, built by Sylvester Marsh, is very similar to that constructed on the Righi by Messrs. Riggenbach & Naeff. It should be mentioned that Sylvester Marsh had first attempted to work Fell's central rail arrangement, but abandoned it soon, substituting for the central rail a rack. The gradients on either railway are often 1 in 4 ; on the average the inclination of the gradients is 11 in 50.

The Righi was a success, and since then no fewer than 25 lines have been built in the world on this principle. Most of them are met in Germany, Austro-Hungary and Switzerland. The aggregate length of these railways is over 100 miles. The gauge is either 4 ft. 8½ in. or 1 meter. Steep inclines of 1 in 5 are met with on the Höllenthal, in Germany, and the Lanfen, in Switzerland.

The rack used by Riggenbach is really a wrought-iron ladder laid centrally between the ordinary rails. It consists of parallel channel irons kept apart by stays of round iron, which constitute the teeth, into which gear the teeth of the wheels on the engine run. The first engine had a vertical boiler, forming an angle with the frames, so that the water level would remain horizontal whatever the inclination of the road might be. The wheels were loose on their axles, but the toothed wheel was keyed on the middle of the rear axle. Motion was transmitted to it by intermediate spur wheels. In subsequent applications the toothed wheels were mounted on a blind axle, for in the previous arrangement it occurred that the ordinary wheels wearing on the tread would interfere with the proper working of the toothed wheel, which gears simply with the rack. In all engines built afterward horizontal boilers were adopted, but arranged in such a manner that the level of the water should always remain horizontal, or nearly so.

The idea naturally occurred that the wheels which run on the ordinary rails might be coupled and actuated by steam. This has been done on nine of the railways built according to Riggenbach's plans. But the merit to have carried this new idea to its fullest extent and improved the rack belongs to M. Roman Abt, of Lucerne. During the last nine years the Abt system has made wonderful progress. No fewer than 19 railways have been built on the Abt system, representing an aggregate length of 194 miles. The longest are the Hartz Railway, in Germany, 18 miles ; the Rama Serajewo, in Bosnia, 42 miles ; a section of the Transandine, in South America, 31 miles ; San Domingo, West Indies, 22 miles. One of these railways—that of Mont Salies, in France—is an electric one. One in 5 gradients, as at Aix-les-Bains, are not infrequent.

The difference between Abt's and Riggenbach's systems consists in the construction of the rack and the fuller utilization of the adhesive weight on the wheels running on the ordinary rails. There are two independent groups of cylinders. Those inside actuate the spur wheels keyed on an intermediate shaft. The outside ones drive the ordinary wheels in the usual manner, these wheels being, of course, coupled. On the portions of the lines which are not too steep, the outside cylinders alone are worked ; on the heavy gradients, the inside or both inside and outside cylinders are used.

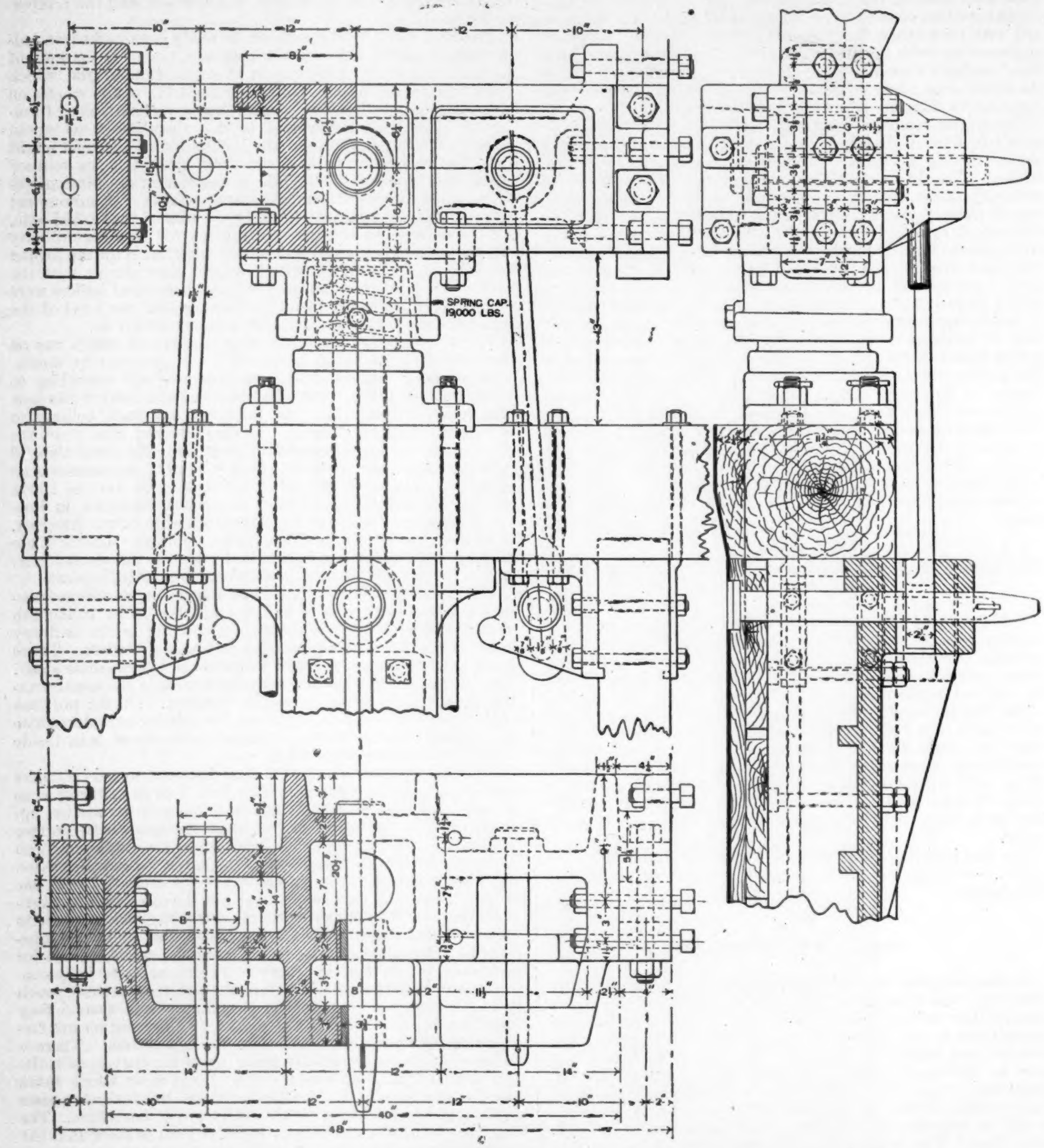
The rack consists of parallel steel bars supported by chairs resting on metallic sleepers. The steel bars are cut out so as to form suitable racks, but the teeth of one bar are not opposite those of the other, but opposite the space between two teeth of it. This arrangement necessitates the employment on the engine of wheels with stepped teeth, but it reduces friction and insures that the spur wheels are always in contact with one or two of the rack bars, which was not the case in the Riggenbach system. The advantages are : First, the rack is easier to make and lay down with accuracy than the ladder arrangement of Riggenbach. The joints, although insistent, can for each rack-bar be laid in alternate chairs, so as to keep continuity and the strength of the rack unimpaired ; second, much sharper curves can be used. In the Riggenbach system they could not be less than 9 chains radius ; 5-chain curves are frequent on the lines laid according to the Abt system. There is no necessity to have specially made parts for curves, as is the case with Riggenbach's rack. The slight wear which takes place on the teeth in the first days after the line is thrown open to the traffic compensates for the difference of curvature. The experience gained on the Hartz Railway goes to show that the rack teeth wear 1 millimeter in 150 years, and the spur wheels last 12 years. The Riggenbach spur wheel lasts only two years. Third, the number of rack bars determines the weight of the trains which can be hauled on such a track ; a greater speed is possible, as there are always teeth in contact with the racks, and consequently no shocks, as in the Riggenbach system. Five miles an hour on the latter causes hammer blows between the wheel and rack teeth, whereas in the Abt system a speed of 15 miles an hour is obtained without shocks or noise. The Abt system has been, so far, a grand success, and it will no doubt receive more extended application. The Beyrout-Damascus Railway, 86 miles long, will be on the Abt system. —*Railway Press.*

ENGINE AND TENDER CONNECTION ON THE PENNSYLVANIA RAILROAD.

We illustrate herewith the connection between the engine and tender which has been designed for use with the Class P. locomotives on the Pennsylvania Railroad. It will be seen that there is a spring of 19,000 lbs. capacity placed in a casting located in the buffer plate of the engine. This spring is thoroughly housed in, so that there is no opportunity for it to get loose or shake out of place. The regular draft rigging consists of the usual pin connections with a bar 4 in. wide and 1¼ in. thick.

The safety arrangement consists of two bars 1⅛ in. in diameter, with slotted pin connections on the engine and a solid pin connection on the tender. This allows for curvature and the usual oscillation between engine and tender, but, should there be a breakage of the regular draft rigging, the distance traveled before the safety rigging would come into action would be but a trifle over 3 in., which is very much less than could be attained did the safety attachment consist of the chain connections.

The matter of safety connections between engine and tender was the subject of a recent report before the Master Mechanics' Association, in which great weight and great strength were recommended. This arrangement is simple, and would seem to meet the requirements as to both strength and rigidity.



ENGINE AND TENDER CONNECTIONS FOR CLASS P, PENNSYLVANIA RAILROAD.

RUSSIAN ENGINEERING NOTES.

A STEAMER FOR RUSSIAN PRISONERS.

The following description of a steamer built in Dumbarton, Scotland, for carrying Russian prisoners, will be of interest to many of our readers. The name of the vessel is *Yaroslavl* and will form a part of the Russian voluntary fleet. The length of the steamer is 420 ft. on deck, with a breadth of beam of 45

ft. The hull is of steel, and there are three decks, the rigging being that of a two-masted schooner. The displacement is 5,100 tons. She is driven by twin screws turned by two triple expansion engines. On her trial trip on the Clyde, when the draft was three-quarters of full load, her speed was 12 knots. This steamer is especially intended for the transportation of prisoners or exiles on the Sachalin Isle. Particular attention has been given to the construction of the prisoners' apartment, which is placed between the hurricane and main deck, and is so arranged that there is a passage of 1 ft. between the planking and the grating.

The openings are large and the number of ventilating tubes quite sufficient, so that an ample supply of fresh air is secured. In case of storms, when ventilators and hatches are closed, two ventilators driven by electricity are placed in operation. In addition to this, supplementary ventilating tubes are arranged for a continuous supply of fresh air. The beds are 2 ft. × 6 ft. and are arranged in two rows. The engine-room is entirely isolated from the prisoners' quarters. The cost of the steamer was £74,000.

She will sail for Odessa and then take on board 800 prisoners, and in Nickolof will take on 2,600 tons of freight for the construction of the Oussouri Railway, whence she will sail for the far east. The vessel was constructed by Messrs. Denny & Co., who have also received an order for another steamer, to be called the *Tamboff*, for the voluntary fleet. This second vessel will be constructed on the same plan as the *Yaroslavl*, but, instead of the prisoners' compartments, she will be arranged to carry emigrants, and the number of first-class cabins will be increased to 60. The contract price for this steamer is £70,000, or £4,000 less than the first one, which is said to be due to the general stagnation in the ship-building trade and great decrease in the price of steel.

THE NEW RUSSIAN IMPERIAL TRAIN FOR FOREIGN TRAVEL.

A correspondent has sent us the following description of a new imperial train for foreign travel, which has been finished at the Alexandrovsk Works of the Nicolai Railroad, in St. Petersburg:

This train consists of 11 eight-wheeled cars—viz., sleeping-car, parlor car, two grand ducal cars for gentlemen and ladies, office car, guards' car, kitchen car, car for attendants, car for electric machines, and a baggage car. The length of each car is about 63 ft., so that the whole train, without engine, is about 700 ft. long.

The peculiarity of these cars is that the bodies of them are built of steel sheets, and each side wall is made of a single sheet. The wood is used only for posts and rafters. This system is designed by Mr. Polonceau, C.E. There was great difficulty in preparing such steel sheets—55 ft. long and $\frac{3}{16}$ in. (5 millimeters) thick, which can be made at the Alexandrovsk Steel Works.

The cars are mounted on two four-wheeled bogies or trucks with a triple system of springs.

The bogies are so arranged that the wheels can be changed, so that the cars can run on Russian tracks of 5-ft. gauge and on foreign roads 4 ft. 8½ in. wide.

The heating of the cars is by steam and the lighting by electricity. The train is provided with dynamo machine and accumulators.

For the safety of travel the train is provided with three systems of brakes—the Hardy, with rarefied air; the Westinghouse, with compressed air, and ordinary hand brakes.

The inner ornaments were designed by special artists and made by the best cabinet-makers, Svirski, Bütcher & Günsberg, of St. Petersburg. The bronze furniture was made at the workshop of Berto.

All the mechanical work has been done under the superintendence of a special committee presided over by the director of the railroad department, Mr. Soumarokov.

All the cars have been sent from St. Petersburg to Warsaw, where they will be put on the foreign track (4 ft. 8½ in. gauge) and will be tried there.

SIBERIAN RIVERS AND NAVIGATION.

When the network of Russian railroads has reached the western boundary of Siberia—viz., when the Oural Railroad has been carried to Tumen on the Toura River—then the economic condition of the country and the navigation on Siberian rivers will be greatly changed.

In former times corn was produced in Siberia exclusively for local consumption; now agriculture has been very much developed, and the export of its products increases every year.

The immigration of settlers from European Russia increases prodigiously. In the year 1885 9,678 settlers passed through Tobolsk; in the year 1892 the number was 100,000; and for the whole period (1885–92) the whole number of immigrants (passing the Tobolsk Government) was 287,956.

The goods traffic through the main water ways Toura and Tobol, being the prolongation of the Oural Railroad, in the period from 1870–84 was 40,000 tons; and it has been continually on the increase, reaching 250,000 tons in 1892. The total freight traffic on the rivers of Western Siberia in 1892 was 330,000 tons.

The number of vessels (barges) on the system of the Obi River has increased with the requirements of traffic.

The first steamer in Siberia was built in 1844, and was the only one till 1854, from which time the number of steamers increased every year, and in 1893 the whole number was 102, the number of other vessels being 200.

The navigation on the Siberian rivers during the last twenty-five years has changed not only in quantity, but also in quality. In old times there were heavy vessels with great draft and small tonnage, going downward with the flow of the stream and upward by means of wire. Now we have only steamers towing the vessels (barges).

The river fleet is now the following: 1 steamer of 250 N.H.P.; 1 steamer of 180 N.H.P.; 4 steamers of 150 N.H.P. each; 8 steamers of 120 N.H.P. each; 9 steamers of 100 N.H.P. each; 18 steamers of 80 N.H.P. each; 11 steamers of 60 N.H.P. each; 15 steamers of 40 N.H.P. each, and 21 small steamers.

The greatest traffic takes place between the upper parts of the rivers Obi and Irtish from the one side, and the city of Tumen (terminus of the railroad) from the other. About all these goods are carried by the Siberian rivers the great distance of from 1,700 to 2,000 miles.

The Siberian navigable rivers being still in their natural state, navigation is dangerous, and the freights and fares are very high—seven to eight times greater than the freights on the Volga River in European Russia.

The control of the Siberian rivers from the year 1809 has been given to the X District of Way Communications. Thirteen years after, when the X district was cancelled, the control of Siberian rivers was divided between the administration of Eastern Siberia and that of Western Siberia. Since that time the administration was occupied only with highways, and nothing was done for the rivers, the control of navigation belonging to the ordinary police. In the year 1882 the administration of Western Siberia was cancelled and its water communications have been transmitted to the Department (ministry) of Way Communications. From the years 1882–93 this department has only superficially studied Siberian waterways.

Such condition of navigable rivers cannot be called favorable navigation; but the Department of Way Communications, having in view the limited resources of the State treasury, must confine the improvement of the waterways to those most necessary—viz., the rivers Yenissey, Lena, Angara, Selenga, Oussouri, while the artificial Obi-Yenissey connection will for the present be left in its present state.

Hydrotechnic works will be undertaken on the following rivers: On the Toura River, from Tumen to its estuary in Tobol; on the Tobol River, from the estuary of Toura to its estuary in Irtish; on the Tomi River, from Kouznetzk to its estuary; on the Choulim River from Achinsk to its estuary.

Besides these the channel (navigable channel) will be marked on the following waterways: Toura River, from Tumen to its estuary; Tobol River, from its estuary of Toura to Irtish; Irtish River, from Semipalatinsk to Tobolsk; Obi River, from Barnaoul to Tobolsk; Tomi River, from Kouznetzk to estuary; Choulim River, from Achinsk to estuary.

Lastly, it is proposed to build a telegraph line from Tobolsk to Krivoshchekova, the point where the future railroad crosses the Obi River (1,500 miles), and make the exact surveys and explorations of Shilka River from Svetensk to estuary, and of Amour River from the estuary of Shilka to the Khabarofka. For the control of this waterway the Department of Way Communications appoints now administrations of water communications of Western Siberia with a territory including 5,000 miles of waterways. For the improvement of the waterways $815,000 has been appropriated, and $250,000 more will be expended each year thereafter.

THE NEW TERMS OF CONSTRUCTION OF THE GREAT SIBERIAN RAILROAD.

In one of the last sessions of the Siberian Railroad Committee, presided over by the successor to the Russian throne, Tsarevitch Nicolas, an acceleration in construction of a through railroad was decided upon. For that purpose a temporary track will be laid from Irkoutsk to Listvinichnaïa, a landing-place on the west bank of Lake Baïkal, and a regular steam ferry connection between this landing-place and the Trans-

baïkal Railroad will be established. This temporary railroad, 53 miles long, will accelerate the time of opening of the through Siberian railroad, for the loop of the Baïkal line located on the south bank of Lake Baïkal is very difficult of construction, and will require very much time for completion. The temporary line will probably remain permanently, after the construction of the loop of the Baïkal line, to supplement the navigation on Lake Baïkal.

The steam ferry on Lake Baïkal will work during eight months in the year, and make a good connection between the Central Siberian Railroad and the Transbaïkal Railroad. But during the four winter months, when Lake Baïkal is frozen and covered with ice, the transportation of goods and passengers over the ice of Lake Baïkal (which is here about 25 miles wide) will be performed on sledges, or by means of a light narrow-gauge track laid on the ice.

In addition to this, a general acceleration in construction of different lines belonging to the Great Siberian Railroad was decided upon; so the Central Siberian Railroad from the Obi River to Irkoutsk, 1,167 miles long, will be completed in 1898 (instead of 1900, as was proposed before). The work will probably be executed in this time, as the local population is available for the construction of railroad works, and the materials for track-laying can be carried not only to the starting-point, Krivoshchekova, on the Obi River, but even to the terminus, Irkoutsk, on the Angara River, and in Achinsk, on the Choulim River. These two rivers, Angara and Choulim, will be improved for that purpose. The plan of construction is as follows: In 1895 the section of the Central Siberian Railroad from Achinsk (on Choulim) to Krasnoïarsk (on Yenissey), 117 miles, will be completed. The rails and other materials for this line will be carried from Tumen through Toura, Tobol, Irtish, Obi, and Choulim to Achinsk. The line from Achinsk to Krasnoïarsk being completed (in 1895), the same materials can be carried to Krasnoïarsk, and from these through Yenissey and Angara to Irkoutsk, and in 1896 the track-laying can be commenced from Krasnoïarsk and Irkoutsk simultaneously. Of course for this purpose the earthwork on the whole line will be undertaken in 1894 and completed during the first half of the year 1895.

RIVER NAVIGATION IN RUSSIA.

According to data compiled by the Russian congress of hydrotechnic engineers, the principal rivers of European Russia carry about 20,000,000 tons of freight in all. These are the official figures, but in consequence of the bad system of registration the real figures are surely double this amount. The Russian railroads now carry about 54,000,000 tons a year, so that the navigation is relatively important.

European Russia (without Siberia) has more than 35,000 miles of navigable rivers and canals, which is more than in the remaining countries of Europe, which, taken all together (France, Germany, Austria, England, Belgium, Holland and Sweden), have only 28,000 miles.

The Russian river fleet is also very great. There are 1,300 steamers, with a tonnage of about 83,000. On German rivers there are only 570 steamers, on Austrian (Danube and its tributaries) only 193. Besides those mentioned, the Russian rivers carry 21,000 other vessels with a tonnage of 6,000,000. Germany has only 18,000 such vessels whose tonnage is 1,300,000. The Donau Company, in Austria, has only 750 barges with 200,000 tons of displacement. The river fleet of Russia is therefore twice as great as the river fleet of all other European countries. The number of ton-miles made by this fleet during the half year of navigation is more than the number of ton-miles made on the railroads during the whole year. The latter in 1890 was about 8 milliard ton-miles.

The quantity of freight carried by Russian rivers (20,000,000 to 40,000,000 tons) can be compared only with that of the United States, where 60,000,000 tons are carried yearly.

GAS POWER ON TRAMWAYS.

These columns have from time to time recorded many attempts to supersede horses on tramways by some form of mechanical power. Steam locomotives, compressed-air motors, secondary batteries, cable cars, and electric underground and overhead systems have all been described. Yet, although often introduced by men of great ability and backed by ample capital, it cannot be said that any one has made an unqualified success in this country, while some have been absolute failures. The question is full of difficulties of a most formidable character. From a commercial point of view the horse is a fairly cheap motor, and anything that aspires to displace him must be at least as cheap. Further, it must not be the cause of nuisance either to passengers or to the general public. It must not occasion either noise, smell, or smoke, or be very unsightly, and it must be under perfect control. Much of the mechanical difficulty arises from the fact that some 10 or 12 H.P. must be provided to do the work of two live horses, and that, therefore, a great weight of machinery must be carried. These various requirements sadly hamper the proceedings of inventors, especially on lines where the traffic is light. Given a sufficient supply of passengers, either the cable or the trolley system answers fairly well; but the initial expenditure is so great that it is only possible when a large and steady revenue can be relied upon.

As a means of working tramways in which a large outlay is impossible, which probably means 90 per cent. of those in this country, there is being introduced by the Traction Syndicate, Limited, of 22 Chancery Lane, London, a self-contained car, fitted with a gas engine and carrying its gas supply compressed in steel tubes. Such a car is now in regular work on the Croydon & Thornton Heath Tramway Company's lines, and will be watched with great interest by all engaged in such matters. It certainly has much to recommend it. The car is not noticeably different from a horse car; it runs quietly and easily, emitting neither smoke nor steam, and is quite under control. Inside passengers can hear a slight rumble of machinery and perceive a trifling vibration, but after a minute or two these are unheeded, and practically there is nothing to detract from their comfort. Neither they nor bystanders in the street can perceive any machinery whatever, for the engine and gearing are entirely enclosed, the motor lying under one seat and the wheels and clutches under the floor of the car. The driver stands on the end platform with the usual brake handle beside him, and in front of him a lever which operates the clutches controlling the gearing. With the lever vertical the engine is out of engagement with the axles; when the lever is placed to one side or the other the slow or the fast gear is in engagement. There is a second lever for operating reversing clutches at the end of the line.

The motor has two cylinders placed face to face at opposite sides of the crank shaft and both driving on to one crank. At one end of the shaft—that nearest the side of the car—is a flywheel, and at the other end a pinion gearing into a wheel on the first motion shaft, which lies under the floor of the car. On this shaft are two pinions, either of which can be made to drive a second motion shaft, the large pinion giving a speed of 8 miles an hour to the car and the small pinion half that speed. Each of these pinions is furnished with a friction clutch consisting of two disks, with a ring of beechwood between them. One disk is set up toward the other by means of bell cranks and spring toggle arms pivoted to a sliding collar, the arrangement being such that when the clutch is in engagement the pressure of the arms is about at right angles to the shaft, and there is no end thrust on the sliding collar. The second motion shaft is geared to the axles by pitch chains. For driving in the opposite direction the rotation of the first motion shaft is reversed by intermediate wheels and claw clutches.

Many of the difficulties connected with a gas-driven car arise from the fact that the engine must not be stopped *en route*, but must run constantly, whatever the car may do. It is, however, susceptible of a certain amount of regulation, and advantage has very ingeniously been taken of this to save gas and to lessen vibration. When the work is light the governor cuts off the gas supply to one cylinder entirely, the other doing all the work. The governor is loaded by a spring on the spindle and also by weights on an external lever, and these weights can be lifted by the same handle that operates the clutches. By this means the speed of the engine is reduced by some 50 per cent. when the car is standing, and, further, the gas admission is delayed until half stroke, with the result that the explosion is rendered much more gentle and less likely to give rise to vibration of the car. The gas is carried in three receivers under an initial pressure of 120 lbs. to the square inch, enough being taken for an 8 to 10-mile run. It is compressed at the Thornton Heath depot by a gas engine and pump, and is kept in a receiver under a pressure of 10 atmospheres. The compressed gas is carried to the car by a pipe and flexible hose, the charging occupying no more time than changing horses. We are informed that the consumption is 25 cub. ft. per mile at the cost of a penny.

The performance of the car is quite satisfactory. It carries 28 passengers in all, and makes a very fair speed, the limit allowed by the Board of Trade being 8 miles per hour. With the slow gear it will readily mount an incline near Thornton Heath Station of 1 in 23, with a short piece of 1 in 16, and in coming down it can be stopped by the brakes in its own length. It also goes round a curve of 35 ft. radius on a 1 in 27 grade. Its weight, filled with passengers, is 5½ tons. The future of

the system turns mainly on the question of maintenance. The first cost of the car with its motor is not greatly different from that of a horse car with its 11 horses. For gas it costs 1*d*. per mile against 3½*d*. per mile for fodder and bedding for horses, so that it starts with an advantage of 2½*d*. per mile. Time must decide whether horseflesh or mechanism is the cheaper to keep in going order. The new motor has, at least, one great advantage over the tramway steam locomotives which, in some districts, have done good service—it has no boiler to be constantly under repair. There are £14,000,000 sterling invested in tramways in the United Kingdom, with very unsatisfactory results as to dividends, so that evidently there is a wide opening for any system that would effect an economy in working. —*Engineering*.

RAILWAY CONSTRUCTION IN JAPAN.

On the occasion of the World's Fair much had been made known about Japan and the habits of the people. The country is undergoing great social, commercial and political changes, and is making rapid strides in improving her means of communication and public works in general. The first railway was commenced in 1870, and there are now more than 1,900 miles of railways working, besides several lines under construction or proposal, which are as follows:

NAMES.	Length of Lines Granted.	Lines Open.	Lines under Construction.	Lines Surveyed.
	Miles.	Miles.	Miles.	Miles.
Imperial Government Railway..	557.61	557.61	......	......
Niphon Railway Company.......	598.24	593.08	5.16	......
Sanyo " "	307.92	145.10	9.65	153.17
Kinshin " "	272.52	136.76	53.50	82.26
Tanke " "	205.09	205.09	......	......
Kansei " "	90.25	59.06	23.50	7.69
Chikuho " "	29.00	25.66	3.34	......
Osaka " "	42.18	32.69	6.21	3.28
Ryomo " "	52.21	52.21	......	......
Kobu " "	26.90	22.96	3.94	......
Hankai " "	6.16	6.16	......	......
Sanuki " "	10.19	10.19	......	......
Kushiro " "	25.86	25.86	......	......
Iyo " "	10.24	7.43	2.81	......
Sobu " "	40.00	......	5.50	34.50
Bantan " "	30.71	......	30.71	......
Nara " "	25.66	......	25.66	......
Sangu " "	22.50	22.50	......	......
Nanwa " "	16.50	......	16.50	......
Kawagoe " "	18.25	......	18.25	......
Settsu " "	14.43	......	14.43	......
Boso " "	11.49	......	11.49	......
Sano " "	9.63	9.63	......	......
Ome " "	13.09	......	13.09	......
Hoshiu " "	43.81	......	43.81	......
Shinkaku " "	17.40	......	......	17.40
Ota " "	13.00	......	......	13.00
Nanyo " "	7.13	......	......	7.13
Dogo " "	2.29	......	......	2.29
Total........................	2590.26	1911.99	287.55	330.72

The standard gauge of Japanese railways is 3 ft. 6 in. The permanent way consists of flat-bottomed steel rails weighing 60 lbs. per yard, laid on cross-sleepers, except 66½ miles for Tokyo-Yokohama and Kobe-Kyoto lines, on which double-headed rails on cast-iron chairs are used. On the Kobe-Kyoto lines cast-iron pot sleepers were first tried, but they were gradually replaced with timber cross-sleepers. Lately, an experiment was made with earthenware sleepers in the Shinbashi station compound. As there is an abundant supply of wood in Japan, and it is not attacked by insects, timber sleepers answer very well. The railways are mostly single lines, with the following exceptions:

Shinbashi-Yokohama Line,	18	miles (double line).
Numadzu-Oyama "	22	" " "
Ueno-Omiya "	16¼	" " "
	56¼	"

The above lines are entirely double-tracked. The earthwork for Kobe-Kyoto Line (47¼ miles) is made for a double way and the bridges single way. All other lines are entirely single lines. Figs. 1 and 2 show the earthwork for single lines. There are 430 stations, of which Shinbashi, Yokohama, Kyoto, Osaka, Kobe, Hiogo, Moji, Yokkaichi, Tsuruga, Naoetsu, Ueno, Omiya, Oyama, Awomori, Temiya, etc., are large stations. These are mostly of wooden buildings, but some are of brick and stone work with iron roofs. There are extensive workshops of the Imperial Government railways in Shinbashi and Kobe, where locomotives and cars are built and repaired. The locomotives are mostly of English manufacture, but there are some American and German locomotives, as well as of Japanese make, the total number for the whole 1,900 miles being 340. The ruling gradient is 1 in 40 (2.5 per cent.), and the sharpest curve, 15 chains.

As the country is mountainous and full of rivers and running streams, there are several engineering works—deep cuttings, high embankments, tunnels, bridges and culverts. In order to carry out earthworks, temporary rails are used. The Japanese coolies are not at all accustomed to use wheel-barrows, but they are well trained to carry earth, stone, or anything on their shoulders with straw net or *mokkō*. In blasting rocks, gunpowder, dynamite and other explosives are used.

Bridges consist mostly of wrought-iron plate or Warren girders, except some brick arches, which are usually constructed in a deep valley or for flood-openings. The usual span of plate girder is 40 ft., and that for Warren girders is 100 ft. But in large rivers, where longer spans are required, Warren girders of 200 ft. span are constructed. The superstructure is of an ordinary character, as shown in fig. 3. When the ground is of a substantial material, concrete foundation is made and masonry piers are built, but in case of soft material usually brick walls are sunk, though cast or wrought-iron piers (from 3 ft. to 8 ft. in diameter) are sometimes constructed. While iron is required to be brought from Europe, bricks are manufactured in every part of the country; thus the latter is preferable in Japan. The brick cylinder foundations for large bridges are constructed in the following way: The wells are usually built to rest on hard stratum, in two columns, 12 ft. in external diameter and 2 ft. thick, differing in depth from 30 ft. to 90 ft. below river-bed, according to the nature of the bed. Through the whole height of the cylinder tie bolts run, and they are fastened to the curb-shoe, whose outer side constitutes a cutting edge. Below the ground level the diameter of the wells is reduced to 8 ft., and it is filled with concrete. From this level, masonry works are carried up to the outside of the girders. The space between the two cylinders is arched over, and an intermediate wall is constructed. To sink the wells, first the brick-work is built on the curb-shoe, which is already placed in its position. A pair of the cylinders forming one pier is usually sunk alternately so as to avoid any great difference of levels of the wells and consequent divergence from the vertical plane. In order to excavate inside the wells, Milroy's, Webb's, and Bull's dredgers were tried, of which the last proved most suitable for its simplicity and ease of using. But in case of gravel bottom it is objectionable on account of stones being caught in the jaws of the dredger, which causes difficulty and prevents it from being pulled up without the contents being run out. It is usual to employ a simple hand dredger made by a contractor, which is skillfully handled by Japanese workmen. When the cylinders are sunk to proper position they are filled with concrete.

The best season for sinking the foundations is from October to the following May, which is the time when the autumnal floods set in and the vernal floods begin from the thawing of ice and snow in the mountains.

It will be interesting to notice the cost of some large bridges on Japanese railways, which are as follows:

NAMES.	Length in Feet.	Total Cost.	Cost per Running Foot.
		Dollars.	Dollars.
Rokugo-gawa Bridge (Tokaido Line).......	1,650	434,906	263.58
Banew-gawa " "	1,368	77,682	56.79
Fuji-kawa " "	1,874	283,360	151.21
Abe-kawa " "	1,830	80,874	44.19
Oi-gawa " "	3,339	409,216	122.56
Tenriu-gawa " "	3,967	507,055	127.82
Hamana No. 3 " "	1,578	64,976	41.18
Yahagi-gawa " "	1,139	64,973	57.04
Kiso-gawa " "	1,874	302,286	161.31
Nagara-gawa " "	1,490	204,271	137.09
Yebi-kawa " "	1,055	181,545	172.08
Aichi-gawa " "	1,305	56,767	43.50
Nosu-gawa " "	1,769	82,633	46.71
Seta-gawa " "	1,450	88,024	60.71
Katsura-gawa " "	1,197	261,633	218.57
Upper Kanzaki-gawa Bridge "	1,297	283,415	218.52
Lower " " "	1,187	279,921	235.82

The tunnels of Japanese railways are usually for a single line, except some short tunnels (on Kobe-Osaka Line) under rivers whose beds became elevated above the surrounding grounds by the deposits of materials brought from the source. The cross-section is shown in fig. 4. Generally the width of springing

of arch is 14 ft., and the height from rail level to soffit of arch is 14 ft. In the Usui-Toge Railway these dimensions were made 15 ft., as a larger locomotive of the Abt system was designed for that steep railway. The tunneling may be briefly stated as follows: At first the top headings of 6 ft. × 5 ft. are made. Then the excavations to the full dimensions are carried on. This is done both by rock drills and hand workings. The archings of the tunnels are from 2 rings to 6 rings, according to the nature of the rock, and below the springing, side walls are built, their back being well rammed with concrete or gravel puddle. Ventilation is kept by means of fans working at the end of a long wooden tube with closed doors. The portals of the tunnels are well constructed with stones and bricks.

The following list gives cost of principal tunnels:

Names.	Length in Feet.	Total Cost.	Cost per Running Foot.
		Dollars.	Dollars.
Hakone-yama No. 2 Tunnel (Tokaido Line)	1,892	115,573	61.09
" No. 3 " "	1,024	61,472	60.03
Ishibe " "	2,865	131,411	45.87
Isohama " "	3,167	210,873	66.58
Makinohara " "	3,273	213,617	65.27
Osaka-yama " "	2,181	203,264	93.20
Nakoe Tunnel (Yokosuka Line)	1,130	34,809	30.80
Numama " "	1,319	41,795	31.69
Yanagase-yama Tunnel (Tsuruga Line)	4,425	425,499	96.16

rikisha (a carriage drawn by a man) is used, which was shown in the Chicago Exposition. The jinrikisha has also been introduced into China and India from Japan. In this way manual power is still being used for some other works. It is known in America that machine is ultimately cheaper than animal or man power. In Japan, too, the latter is gradually being replaced by the former.

The motive power at present used in the country is as follows:

Steam-power, 38,000 H. P.	{	General workshops,	26,000 H. P.
		Mining,	12,000 "
Water-power, 5,700 H. P.	{	General workshops,	3,100 "
		Mining,	2,600 "
43,700 H. P.			

In the above figures the power used for the propulsion of railway cars and steamships is not included. As there is a convenient supply of water in mining districts, water power is generally used there. In countries like Switzerland and Japan, where there is a natural supply of energy, it is economical to utilize it, especially with the aid of electric motors. It is owing to the advancement of electrical engineering that this problem is now entering into the field of practical engineering. Thus, water-power can be derived in a great many different ways—*i.e.*, from the most primitive form of water-wheel, having only two buckets—still to be found in some country districts of Japan—to the great installation of turbines and dynamos at the Falls of Niagara. An example of an artificial canal for deriving water-power is seen in the Kyoto Canal Works, which were illustrated in THE RAILROAD AND ENGINEERING JOURNAL for March, 1891. This work is calculated to produce 3,000 H.P.

EMBANKMENT

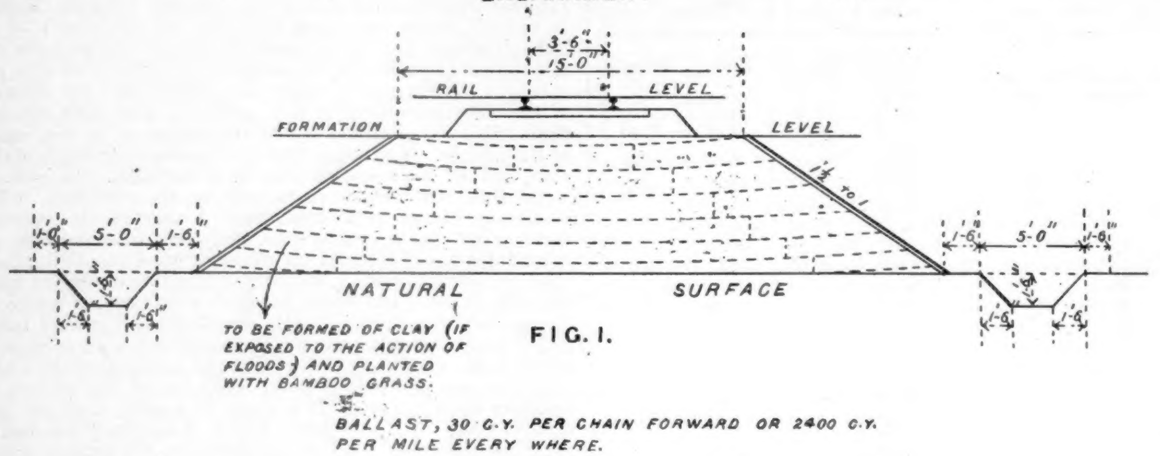


FIG. I.

CUTTING

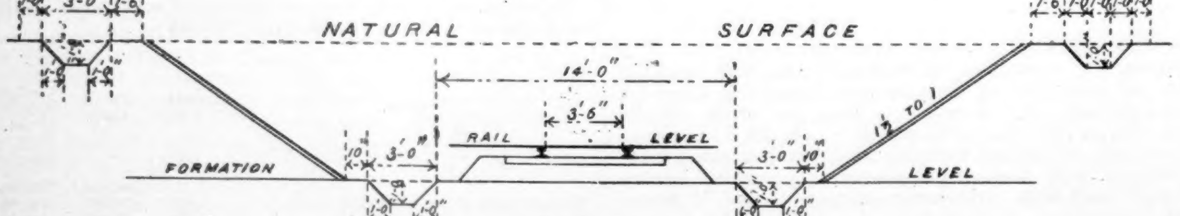


FIG. 2.

Of the average cost of one mile of Japanese railways, it may be mentioned that for the Imperial Government railways the cost (an average for 557.61 miles) is $63,475, and for the Niphon Railway Company the cost (an average for 593.08 miles) is $33,468. The former has more bridges and tunnels than the latter. For all other private lines a fair average cost per mile may be said to be from $45,000 to $50,000. The traffic receipts of the Imperial Government railways is $150 per mile per week, and that for the Niphon Railway Company, $90.

MOTIVE POWER IN JAPAN.

The Japanese islands are generally within the easy reach of steamers, and there are main trunk lines of railways almost completed with roads connecting important towns and localities which are gradually improved. In some cities and towns there are tramways. But in every part of the country jinrikisha (a carriage drawn by a man) is used, which was shown in the Chicago Exposition.

Although in Europe and America coal is generally found in the carboniferous strata, it is not the case in Japan. It is seen from the marine nature of the strata that some parts of the country were sunk beneath the primeval ocean, and had not land for dense vegetation. In rocks of the Mesozoic era, which follow the carboniferous strata, some coal seams are found, but they are not valuable. In the Cainozoic strata, especially associated with tertiary formation, there are many important coal fields which are scattered in various parts of the country. Among these fields, those in Hokkaido and Kiushiu are most productive, the rich seams being from 4 ft. to 8 ft. thick. In these coal districts coal-mining has been established and railways built, and they are working with great success.

The total annual production of coal in Japan is 3,000,000 tons. Out of this amount, 120,000 tons are used for railways, 530,000 tons for steamships, 520,000 tons for workshops, 480,000 tons for manufactures of salt, and the remaining 1,350,000 tons are exported to China, India, America, etc.

Besides being derived from coal, power has another source, namely, forests, from which wood and charcoal are obtained. The quantity of wood which is consumed as fuel and charcoal in Japan is enormous, amounting to 47,400,000 tons per year. Out of this amount, 40,000,000 tons are for domestic use, 650,000 tons for the manufacture of tea, 1,900,000 tons for the manufacture of silk, 4,850,000 tons for mining and smelting

BRIDGE

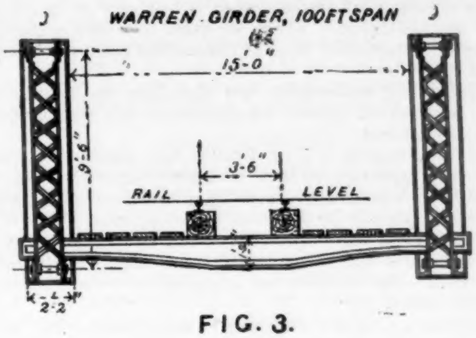


FIG. 3.

TUNNEL

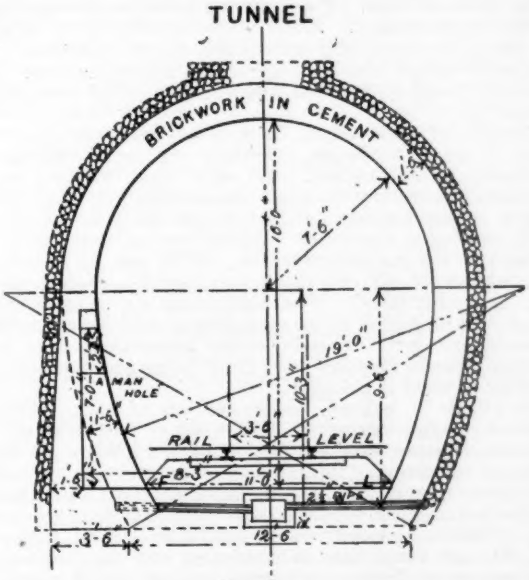


FIG. 4.

works. Thus the forests are the principal source of heat and power in Japan. But it is a well-known fact that to destroy the forests of a country is to destroy its rivers, so that proper care is now being given to them. There are good forests in Central Japan and thick forests in Hokkaido, which are not within easy reach from harbors or railways. If railways be constructed for facilitating the transportation of wood in these forest districts, there will be great advantage. It is hoped that these three elements of power—*i.e.*, water, coal and wood—will be utilized so as to meet the requirements in various parts of the country.

THE MOTIVE POWER REQUIRED FOR AN ELECTRIC RAILWAY.

L'Électricien recently published a long article on the electric railway running from Lyons to Oullins, in France, in which a calculation was made of the motive power required on an electric tramway using the overhead trolley wire. The first step to be taken is to settle upon the frequency with which cars are to start from the two ends of the line, as well as the maximum and average speeds to be maintained. When this is laid down graphically the number of cars in service can be readily deduced. The calculation of the motive power required for each car for the round trip is based upon the estimate of 20 lbs. per ton for resistances on a level track, and 10 lbs. per ton for each 1 per cent. of gradient, and finally by adjusting the power required so as to adapt it to the speeds of the car upon the grades and level stretches. If then we apply the formula that is applicable to the different points along the line, it will be easy to construct a polygon whose area will be enclosed between lines that represent the amount of work required to keep the car in motion. By referring this to the graphical representation of the running cars it is possible to determine the amount of power required by each car at each instant, as well as the total power required by the whole number of cars at the same instant. If the matter is carefully done these calculations should be made at one minute intervals for a round trip. In this way we will find the maximum, the mean, and the minimum power required, it being possible that the last may be zero. The figures thus obtained only indicate the power which must be applied horizontally to the axles of the cars. In order to obtain the power which will be required at the station we must take the efficiency of the different portions of the system into account, and this may be rated as follows: Motors and gearing, 70 per cent.; line, 90 per cent.; generating dynamo, 90 per cent.; steam-engine and belting, 85 per cent.; giving an average efficiency of 48.2 per cent. We may, therefore, consider that we utilize about 50 per cent. of the H.P. indicated at the cylinder of the engine.

Practically these calculations are very quickly made, because experience has shown that a certain number of kilowatts will be required for a given number of cars, and that almost entirely independent of the profile. The following figures may be taken as typical:

Generating dynamo, 60 kilowatts, 4 cars.
" " 100 " 6-7 "

It may be readily understood why this should be the case, because when there are up grades in one direction they become down grades on the return trip, and the car will require no current while running over them. The calculations will be very nearly exact, for no account is taken of the times when the current is shut off. It is admitted, too, that it takes as much current to bring a car from a standstill up to speed, as it does to ascend a 3 per cent. grade at a speed of 7½ miles per hour. In any case the figures obtained by this method of calculation are valuable, because they show the great variations in power that may occur, and that the regulation of the steam-engine should be very sensitive in order to meet the sudden variations in load to which it is subjected. In fact, it is not an uncommon thing in the central stations of electric tramways, to have the needle of the ampère meter vary suddenly one way or the other by as much as 150 ampères. It is, therefore, desirable to know the relationship that exists between the maximum and the mean motive power. If this ratio rises above two, as occurs in lines running only four or five cars, the best steam-engine to use is one of the high-speed type, having a very heavy fly-wheel. The advantage of using a high-speed rather than a low-speed engine for such work as this is, of course, apparent to any one who will think about it. For however sensitive the valve regulation may be in fixing the point of cut-off, it acts upon the admission valve and can only make its influence felt near the beginning and end of the stroke; hence, it is certainly more rapid in an engine making 250 revolutions per minute than in one making 60.

When the ratio of maximum to average power is included between 1½ and 2, as when from six to eight cars are run, a slower engine can be used if it is provided with a very heavy fly-wheel. Above eight cars the best engine to use is one of the Corliss type, for the suddenness of the variation from maximum to minimum is greatly reduced.

These opinions have recently been confirmed by a visit to a central station of an electric railway, where a dynamo of 50 kilowatts nominal power at 600 revolutions is driven by a steam-engine running 120 revolutions per minute. The fly-wheel of the engine is very small, both in diameter and weight; under these conditions it is easy to detect a variation of 50 per cent. in the speed of the engine, which occurs at regular intervals corresponding to the stopping and starting of the cars; yet the stops being fixed, and none being made on signal, the variations in the work to be done are not as great as would occur under other conditions.

The power for running the Lyons-Oullins Railway was calculated in this way, and it was found that from 120–160 H.P. would be required at the central station in order to operate from six to eight cars. Under these conditions an engine of 150 H.P. was required, with a capability of rising to 200 H.P. for short intervals in case of necessity.

TRANSMISSION OF POWER, WITH AN ANALYSIS OF COMPOUND AIR COMPRESSORS.

By A. E. Chodzko, M.E.

GENERAL REMARKS ON THE TRANSMISSION OF POWER.

The transmission of power ranks among the most important subjects which have, during the past thirty years, engaged the attention of the engineering profession. This problem, in whatever particular form it occurs, can always be reduced to the following general terms:

To convey and distribute a certain amount of power which can be more conveniently generated at some distance from the points where it is used than it would be in their immediate vicinity.

This class of questions is a direct outcome of the fact, which needs no demonstration, that a large aggregate power, if generated at a great many different points and in small amounts at each of them, is more expensive to produce than if the whole was generated in a single motor. Such is the origin of the central power station, and the problem is: How to convey power therefrom, either to a number of different places or to one other single place. Any practical answer to this question constitutes a system of power transmission.

A system of power transmission is essentially formed of four distinct elements:

1. A generator of power, situated at a central station.
2. An active medium wherein this power is concentrated, whose object is to transfer it to its destination.
3. A conductor or passive conveyer of this medium.
4. Motive apparatus to utilize the conveyed energy.

It is not the intention to enter into a detailed study of the various systems of power transmission; both the quantity and the nature of the problems involved in such a work exceed the scope of the present paper, and only an outline of the subject will be offered.

Six principal mediums of power transmission are known at present whenever the distance between the generator and receptors exceeds the limits of a factory. These are: (1) Traction by wire rope; (2) water under pressure; (3) steam; (4) gas; (5) electric current; (6) compressed air.

The generation of power is effected either by steam or by a fall of water; in gas transmissions heat is also a primary agent. But if one considers the correlation between the velocity of motion in these various mediums, over conductors, and the size of these conductors, a distinctive line may be drawn between the rope system and the five others—namely, in the former the velocity with which the active medium is carried over a conductor does not in any way affect intrinsic energy. In other words, a pull, or tractive effort of 100 lbs., exerted at the generator end of a teledynamic transmission, would be integrally conveyed by the rope to the receptor end, whatever be the length and the size of this rope, and also the rapidity of conveyance, if there were no intermediate sheaves between the two ends of the rope. The resistances due to the friction of sheaves or to the flexure of the rope would be concentrated at the terminal sheaves, but not generated at the conductor.

The result is that a high efficiency is not only consistent with high velocity and a small conductor, but within the limits of safety and of resistance; such are the very conditions of high efficiency in a teledynamic transmission, because a high velocity of motion means a small tractive effort for a given power, and consequently diminished friction in their bearings, and a reduced size of rope proportionally reduces stiffness or resistance to bending.

Some remarkable applications of this system have been in successful operation for a number of years past. More recent and no less important illustrations are found in the cable roads and in the various systems of aerial ropeways for transporting ore and the like.

Taking now the five mediums for transmitting power, one finds water, steam, gas and compressed air. The energy of these mediums obtainable at the points of application, compared with energy at the generator end, is directly affected by the size of the conductors and the rapidity of motion of the active medium, and the resistance occurs on the whole length of the conductors, increasing with their length; here a condition of high efficiency for a given power and a given size of conductor is, that the velocity of the active medium be limited to a point beyond which this efficiency falls rapidly.

The resistance to the free flow of an electric current is also greatly affected by the size of the conductor, and varies inversely with the size, and proportional to the length.

The above distinction between the first system and the five others should not be construed as a criticism of the general efficiency of each system, but only as a peculiar feature inherent to the different natures of the active mediums.

Present knowledge of the subject does not permit us to formulate limitations of distance to which the power can be transmitted. We are no doubt on the eve of important developments in this respect, and the results of the contract between the Niagara Cataract Company and the State of New York for a 300-mile electrical transmission will be eagerly watched by the engineering world. What the future has in store from the discoveries of Nikola Tesla and others is now a matter of speculation.

So long as the distance is not great between a generator and the receptor, any one of the above systems may be applied. No absolute rule could be given suitable to all cases, as a guide in the selection between them, because no such rule exists; the distance of transmission is but one of many conditions to be considered. There are cases in which water has an uncontested superiority over an elastic and compressible power medium.

The following statements are therefore applicable to the general problem of power transmission, and remain open to possible exceptions.

When the distance is 3 or 4 miles, the choice between the systems of power conveyance is narrowing down, and when power is to be transmitted 10 or 20 miles, electricity and compressed air appear to be the most advantageous. One class of applications exist which have been the subject of exhaustive experiments and have furnished some highly valuable and positive data—the distribution of power over a concentrated field, as in cities.

In this case the central station and each receptor are not connected in the most direct way, but a main conductor is spread out into branches involving numerous changes in the direction of the course or flow. These circumstances render rope transmission impracticable. Water is also unsuited on account of the loss of pressure and contraction of the passages. The danger of frost is also an impediment in most places. The choice is therefore between steam, gas, electricity and compressed air.

Changes of temperature have much influence upon the energy of steam, while gas, electricity and compressed air are unaffected by temperature. But aside from this fact, which is a serious objection to steam transmission, all fluids under tension confined within conductors are liable to escape and waste, causing a direct loss. In the case of steam such loss occurs by leaks and heat radiation. With gas, by leaks only. With electricity, all over the conductor if a contact occurs with some other body. With compressed air, by leaks only.

Complete insulation of the conductor is required in electrical transmissions; with air and gas the joints alone have to be guarded. Steam requires both close joints and insulation or covering to prevent radiation.

The effects of leakage, besides the loss of energy, involve personal danger, damage to surroundings and property by heat and moisture, eventual danger of fire. With gas, there is danger of personal injury, danger of fire and explosion. With electricity, danger of personal injury, serious danger of fire if contact exists between conductors and their surroundings. With compressed air, no bodily injury, no danger of fire. The pre-heater used in connection with the receptor is a small apparatus under easy control, because it is in operation during working time only. In this respect c mpressed air is distinctly superior to other mediums of transmission.

Investigating next what becomes of the transmitting medium after it has performed its work, one finds: Steam has to be condensed or conducted into the atmosphere clear of all surroundings. Gas is deleterious, and must also be conducted clear of surroundings. Electricity has no objectionable effects so long as insulation is effective. Compressed air produces beneficial effects by a supply of fresh air in the premises, and by utilization for various purposes.

One feature wherein compressed air stands above all other means of power conveyance is in the possibility, when employing proper apparatus, of obtaining a practically perfect working efficiency. The result is mainly due to the fact that it is possible to introduce additional energy before using in a motor or engine, and this is done with no objection or expense worth considering. Compressed air, therefore, presents more elements of economy, safety and convenience than any other medium of power conveyance in a city or circumscribed district. From the consumer's standpoint its advantages are even greater than the engineer's.

Experience has shown that an air motor will start instantly after any length of stoppage, which is seldom the case with a steam engine, and still less with a gas engine. The absence of the noise and offensive odors is a great advantage, also the saving of space and the reduction of insurance rates makes an

air motor a typical one for small industries, especially for work carried on in workmen's houses or small workshops. The origin of fires in industrial buildings is commonly traced to a boiler-room in the basement.

In addition to transmitting power, the exhausted air can either remain at the outside temperature and ventilate a room or shop where the work is done, or in the cold season the fresh air, by adjustment of the point of cut-off, can escape at any warmer temperature desired.

On the other hand, as pointed out by Professor A. W. B. Kennedy, is the case of a Paris restaurant where compressed air, after actuating an electric-light plant, was exhausted through a brick flue into the beer cellar; in this flue the carafes were set to freeze, and large molds of block ice were made for table use, while the air was still cold enough in passing away through the beer cellar to render the use of ice for cooling quite unnecessary even in the hottest weather.

The advantages of this mode of power transmission, it is strange to say, are little known, and erroneous ideas prevail about the efficiency of air as a motive medium.

AIR COMPRESSORS.

Up to a comparatively recent date, applications for compressed air were confined to mining and tunnel works, mainly in rock drilling, and less frequently in driving underground hoisting, haulage or ventilating plants. As a rule all the machinery constituting the motive machines employed was of the crudest and most uneconomical description. In both rock drills and underground engines the air was used with little or no expansion, and allowed to escape at a high pressure.

In the course of his investigations on the subject of power transmission, Professor Riedler quotes the efficiency of small mining plants as reaching only 10 to 15 per cent. of the power applied to the compressors. Even in large tunnel works, where high-class single-stage compressors were used, the proportions of 22 to 32 per cent. were for a long time considered as the best efficiency obtainable in the practice, according to whether the air pressure was high or low, and the logical conclusion of this was that low air pressure was an element of high efficiency.

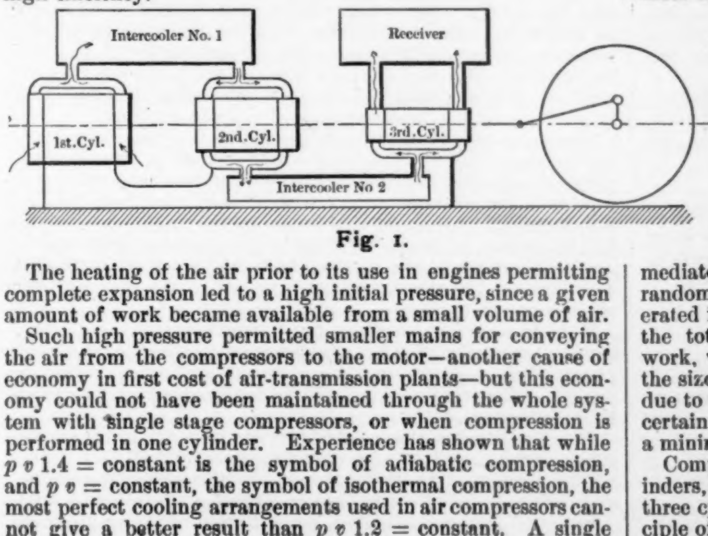


Fig. 1.

The heating of the air prior to its use in engines permitting complete expansion led to a high initial pressure, since a given amount of work became available from a small volume of air.

Such high pressure permitted smaller mains for conveying the air from the compressors to the motor—another cause of economy in first cost of air-transmission plants—but this economy could not have been maintained through the whole system with single stage compressors, or when compression is performed in one cylinder. Experience has shown that while $p\,v\,1.4 =$ constant is the symbol of adiabatic compression, and $p\,v =$ constant, the symbol of isothermal compression, the most perfect cooling arrangements used in air compressors cannot give a better result than $p\,v\,1.2 =$ constant. A single stage compressor with spray injection shows 0.845 as the highest attainable efficiency for seven atmospheres absolute, the efficiency of an isothermal compressor for the same terminal pressure being 1.

What preheating had done at the motor end of the transmission was effected at the generator end, although to a less degree, by the multiphase expression—*i.e.*, by compressing successively into several cylinders, and also by the use of a positive motion of the valves. This class of machines, known by the name of compound compressors, must be considered as an essential and imperative element in the compression of air. The efficiency of a triple compound compressor for the above-quoted terminal air pressure would be found equal to 0.95.

It may be safely asserted that except for moderate pressures, or when the question of economy of power is clearly superseded by considerations of first cost and the simplicity of the plant, the compound machine must be regarded, not as it often is, an object of unnecessary perfection, but as the rational type of modern compressors. This fact had been recognized by the pioneers of compound compression in America, the Norwalk Iron Works of South Norwalk, Conn., and it is creditable to them to have pointed out, at a time when this subject was imperfectly known, that the exception should be the single and not the compound compressor.

It has been thought that a summary of the principles of compound compression would prove of interest, and it is the subject of the second part of the present paper. While the use of thermodynamical formula is unavoidable, the following developments are offered in such a form that ordinary mathematical knowledge will render their perusal easy.

COMPOUND AIR COMPRESSORS.

As stated in what precedes, the most successful way of increasing the efficiency of air compressors is by compounding the cylinders, or by a distribution of the total work required in compression between several distinct cylinders.

The principle of compound compression can be described as follows: Suppose that a certain volume of air at a temperature T_0 is to be raised from a pressure P_0 to a pressure P, P_0 being most commonly the atmospheric pressure of 14.7 absolute pounds per square inch.

In ordinary or single-stage compressors the free air is introduced and compressed in one cylinder, and then delivered directly into a receiver. In the compound machine this air is compressed in a first cylinder from its initial pressure P_0 to a certain pressure P_1, smaller than the terminal pressure P; there will be a certain amount of heat generated by this compression, less, however, than in a single cylinder machine.

The air at pressure P is forced from the first cylinder into a refrigerator, wherein, without losing its pressure, it is cooled down to its primitive temperature T_0, its volume being reduced accordingly. It then enters a second cylinder, where it is compressed from P_1 to another pressure, P_2, still smaller than P, then cooled down again to T_0, and so on compressed by successive stages until the final pressure P is reached, and the air delivered from the last cylinder into the receiver.

Compound air compressors thus consist of any number n of cylinders, whose size is gradually decreasing, with $(n - 1)$ coolers interposed between them, the air being always cooled down to its primitive temperature before passing from one cylinder to the next. The diagram (fig. 1) represents this series of successive compressions and of intermediate coolings.

The result of this combination is that the total heat of compression to be got rid of is divided into several fractions, the series of cylinders presenting to the cooling water, destined to absorb this heat, a greater surface than would a single cylinder, and the air being always cold when entering any cylinder in the series.

There is not, at a first glance, any special rule governing the size of the successive cylinders, and consequently the values of the intermediate pressures, and these quantities might be chosen at random, but when adding the partial amounts of heat generated in the successive cylinders, their sum, which represents the total heat of compression, and consequently the total work, would not, of course, be the same, whatever might be the sizes of the cylinders, and since accepting the complication due to their larger number, it is expedient to know whether certain particular sizes and intermediate pressures do not give a minimum value for the total work of compression.

Compounding has so far been done with two successive cylinders, and one intercooler for usual air pressures; however, three cylinders are employed for high pressures, and the principle of compound compression being independent of the number of cylinders, the question will first be solved generally.

Calling:

J the Joule's equivalent $= 772$.

W the weight of air introduced in the first cylinder.

C the specific heat of air at constant pressure $= 0.2377$.

$T_0, T_1, T_2 \ldots\ldots T_n$ the absolute temperatures corresponding respectively to the absolute pressures.

$P_0, P_1, P_2 \ldots\ldots P$ the absolute initial pressure in each respective cylinder, the total adiabatic work (compression and delivery) effected in the first cylinder will be:

$$J\,W\,C\,(T_1 - T_0) = J\,W\,C\,T_0\left(\frac{T_1}{T_0} - 1\right)$$

The total work in the second cylinder will be:

$$J\,W\,C\,T_0\left(\frac{T_2}{T_0} - 1\right)$$

in the third cylinder:

$$J W C T_0 \left(\frac{T_2}{T_0} - 1\right)$$

and in the nth or last cylinder :

$$J W C T_0 \left(\frac{T_n}{T_0} - 1\right)$$

Since the initial temperature T_0 is the same in all cylinders, as $J W C$ are constant quantities, and as T_0, being the temperature of the atmosphere, can also be considered as constant at a given place and time, the minimum amount of work will be developed when the sum of the partial work is a minimum, or when

$$(T_1 + T_2 + T_3 + \ldots\ldots + T_n)$$

is a minimum.

Now 1.4 being the ratio of the specific heats of air at constant pressure and at constant volume, we know that in adiabatic compression the ratio of the final to the initial absolute temperature is equal to the ratio of the final to the initial pressure, raised to the power $^{0.286}$. Writing this relation for every one of the (n) cylinders of a compound compressor, and multiplying respectively the first and second members of these (n) equations, we find that the product of the terminal temperatures depends solely upon the initial temperature, the atmospheric pressure and the receiver pressure—*i.e.*, that this product is constant in each particular case.

But the sum of a number of variable and positive factors, whose product is constant, becomes a minimum when these factors are equal ; the total work of a compound compressor will therefore be as small as possible when the initial and final temperatures are the same in all the cylinders, or, in other words, when the total work is equally divided among all the cylinders, whatever be their number. As before stated, the two-cylinder compound is by far the most commonly used, and it shall be dealt with more particularly.

Without developing the details of the calculations, it shall be stated that in this compressor, which has one intercooler, the first cylinder, into which the compression begins, is called the low-pressure cylinder, and the second cylinder, wherein the compression is completed, is termed the high-pressure cylinder.

The intercooler pressure must be a mean proportional between the atmospheric and the receiver pressures—*i.e.*, if P_1 designates the absolute intercooler pressure, P_0 and P the atmospheric and receiver pressures, we must have :

$$P_1 = \sqrt{P P_0}.$$

The volume V_0 of the L. P. cylinder and the volume V_1 of the H. P. cylinder, in which the initial temperature is the same, are connected by the isothermal relation :

$$V_1 = V_0 \sqrt{\frac{P_0}{P}}.$$

If the stroke of both these cylinders is the same, which is generally but not necessarily the case, the equal repartition of the total work between them leads to conclude that at any point of the stroke the loads on both pistons are equal ; and if we compare the terminal load on the piston of an ordinary compressor to the aggregate terminal load of a tandem compound machine raising the air to the same receiver pressure, the ratio of the former to the latter will be found equal to :

$$\sqrt{\frac{P}{4 P_0}} + \frac{1}{2},$$

P and P_0 being, as above, the absolute receiver and atmospheric pressures, if $P = P_0$—*i.e.*, if there is no compression at all, this formula becomes equal to 1.

Comparing now the work developed in a single cylinder and in an equivalent compound set, we shall find that when the ratio of the receiver pressure to the atmosphere is :

5 6 7 8 9

and if the work developed in the compound is 1, the adiabatic work with no cooling in the single cylinder is respectively :

1.131 1.147 1.16 1.175 1.185,

showing a gain in favor of the compound of :

11.5% 12.8% 13.8% 14.9% 15.9%,

which increases, therefore, with the receiver pressure.

If the cooling during compression is as perfect as practicable —*i.e.*, if the compression curve is $p\, v^{1.2}$ = constant, the work of the compound being 1, the work of the single cylinder is respectively for the above receiver pressures :

1.069 1.081 1.089 1.095 1.102,

showing a gain in favor of the compound compressor of

6.4% 7.5% 8.2% 8.7% 9.2%.

When the cylinders are cooled externally by means of a jacket, which is an almost general practice in America, the percentage of work gained by the use of a compound compressor can be taken, with a convenient degree of approximation, as :

8.95% 10.2% 11% 11.8% 12·5%.

These figures show that the economy of compounding for the usual air pressures ranges from 10 to 12 per cent., by no means a neglectable quantity, especially for compressors of great power.

It may be here noticed that the preceding results were based upon the assumption that no variation of pressure occurred between the two cylinders ; in practice the capacity of the intercooler has some influence upon the intermediate pressures, comparable, to some extent, to the " drop" that takes place in the receiver of a compound steam engine.

The relative connections of the pistons—*i.e.*, either tandem set or quartering, also affects these variations of pressure, whose effect is to impair the equal repartition of the total work between the cylinders.

These points, whose close investigation would belong to a didactic treatise on the construction of air compressors, can only be mentioned here.

It will be found that the gain increases with the number of stages adopted for the compression ; but it should also be borne in mind that the various resistances increase with the number of cylinders, to say nothing of the cost of purchase and maintenance ; discrimination must therefore be used in combining these conflicting elements, and it is hardly probable that the use of a triple compound machine would be advisable as long as the terminal pressure does not reach 9 atmospheres absolute, and even then unless the compressor be of considerable power. But as a rule, and in all cases, it appears that the single-stage compressor absorbs more work than the compound to produce a given amount of air at a given pressure.

Summing up the above conclusions, we see that compounding increases the efficiency of a compressor on two distinct grounds : In the first place, the heat generated during the process of compression is thus more readily absorbed, because the aggregate cooling area is larger in the compound, whose L. P. cylinder is always the same as the cylinder of the single-stage compressor of the same capacity and piston velocity, and also because the amount of heat subject to the action of this cooling area is smaller.

This, however, is not the only advantage ascribable to the compound machine ; it has also been shown that the maximum piston load was less in this latter compressor than in the former. The result thereof will be best understood in a practical illustration.

Fig. 2 represents the adiabatic cards of a 12" × 16" single-stage machine, and of a tandem compound (12" + 7¾") × 16", both compressing to 70 lbs. gauge ; it also shows the expansion curve in a 12" × 16" steam cylinder, developing with steam at 80 lbs. gauge, a work equal to that of the single-stage air cylinder.

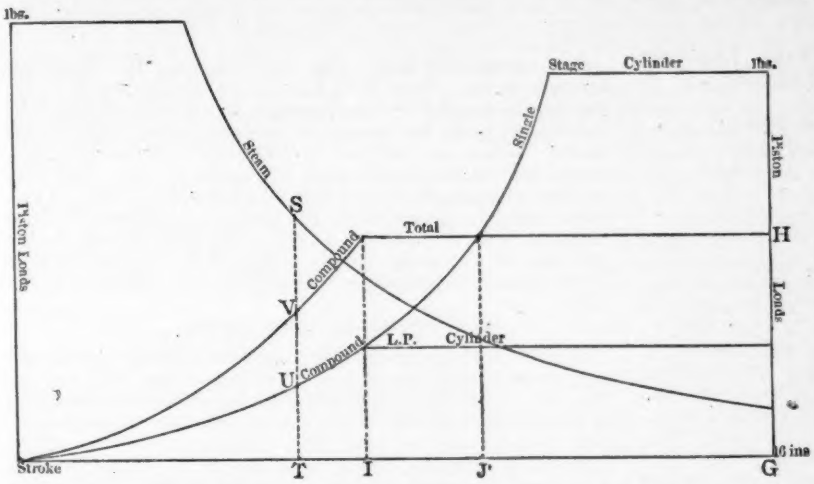
These cards, which are theoretical, do not show the variations of pressure, but the effective loads on the piston-rod, either of the single-stage air cylinder or of the tandem-compound set of air cylinders, or of the single steam cylinder, and they will serve for the comparison of two direct-acting steam compressors, one of them in the single stage and the other in the compound system.

As we know, these cards show a less aggregate piston load in compound set than in the single air cylinder, and as the initial loads are the same range of variation is less in the compound, hence already a reduction in the size of the piston-rods and also of the crank-pin and connecting-rod. But it will be noticed that the compound curve has a sharper rise, since the maximum load $H G$ is reached at the point I of the stroke, while in the single cylinder this same load is only reached at the point J^1.

The result of it is that during this portion of the stroke, which precedes the points of equal loads in the two compressors—that is to say, the point of intersection of the steam and air curves, the difference between the loads on the steam and air pistons is smaller in the compound, where it is $S\ V$,

than in the single-cylinder compressor, where at the same point, T of the stroke, the difference is $S\ U$.

The same may be said for the second portion of the stroke, except in the region $I\ J^1$, but here the discrepancy is unimportant, the piston loads being but little at variance in the two compressors, and this region corresponding precisely to the maximum velocity of the pistons. As the mass of moving pieces, whose momentum is resorted to for securing a regular motion, is a direct function of the actual difference between the loads on the steam and air pistons, we see that lighter pieces will be required in the compound than in the single compressor.



It might be observed that the work absorbed in compression being less in the compound, a smaller steam cylinder should be used; actual practice shows, however, that the same size of steam cylinder is adopted for a given dimension of the L. P. compound or of the single air cylinder, the point of cut-off being, of course, variable.

A longer expansion of steam, combined with a less weight of machinery, concur in winning for the compound compressor the deserved claim of being a better balanced and more economical machine that the single-stage compressor.

The determination of the size of the intercooler in various cases, the influence of the valve areas and of the arrangement of the cylinders upon its proportions, the computation of the amount of cooling water, and a study of the positive valve motion, are as many subjects of practical interest which should be dealt with in a complete investigation of the compound compression, but whose treatment would extend the size of this paper beyond reasonable limits.

The above developments will, it is hoped, suffice to show that the economical production and utilization of compressed air are governed by very precise rules, and favored by such an array of practical advantages that its extensive use as a means of transmitting motive power seems to present itself foremost among the prospects of a near future.—*Industry.*

MARINE NOTES.

Draining of the Zuyder Zee.—The royal commission of Holland, which has for a long time been engaged in draining the Zuyder Zee, has just completed its work. Twenty-one members out of 26 approve of the project. The surface to be drained is about 72,782 acres, whose value is placed at $130,000,000. The total expense is placed at $106,000,000, which includes the expense of works for protection and the payment of indemnities to fishermen in the Zuyder Zee. The drainage will be accomplished after the construction of a dike uniting Holland with the western point of Friesland. The commission is unanimous in recommending the execution of this work to the Government.

The "Priscilla."—The new Fall River steamer *Priscilla* is now in commission, and making regular trips between New York and Fall River. The vessel is one of the finest running out of New York Harbor. It was built under the personal supervision of Mr. G. Pierce, Supervisor of the Old Colony Railroad Company. Her hull is constructed of steel, with a double bottom, having 56 water-tight compartments. Besides which the hull is divided above the inner bottom and at the ends of the vessel by means of bulkheads extending to the main deck, and by flats into 6 additional water-tight compartments, making 62 in all. The main engine is a double-inclined compound surface-condensing type of 8,500 maximum H.P. There are two high-pressure cylinders each 51 in. in diameter, side by side forward of the main shaft, and two low-pressure cylinders each 95 in. in diameter side by side aft of the main shaft, all having a stroke of 11 ft. The vessel is equipped throughout with Blake pumps. The paddle-wheels are of the feathering type, 35 ft. in diameter outside of the buckets. There are 13 curved steel buckets in each wheel, each bucket being 5 ft. deep by 14 ft. wide. The main boilers are 10 in number, of the single-ended Scotch type, and were built for a maximum steam pressure of 150 lbs. There are five decks—main, saloon, gallery, break and dome—on which are located 361 state-rooms for passengers and 35 officers' rooms, making a total of 396 state-rooms. The style of decoration throughout the greater part of the steamer is that of pure Italian Renaissance. The quarter-deck is very spacious, with a floor laid in marble mosaics. From the quarter-deck the grand staircase leads to the main saloon. It is made of solid mahogany, with strings of railing of wrought iron. Here are the ticket office, barber shop, coat-room and entrance to the dining-room lobby. The walls of the quarter-deck are finished with mahogany and ornaments and panels of papier maché, representing by groups of figures in low relief commerce, arts and sciences. The cost of the vessel was $1,500,000. She is licensed to carry 1,500 passengers. The following are some of the principal dimensions of the vessel:

Length over all	440 ft. 0 in.
Length on water-line	424 ft. 0 in.
Beam on water-line	52 ft. 6 in.
Width over guards	93 ft. 0 in.
Depth	20 ft. 6 in.
Draft, loaded	13 ft. 0 in.
Displacement tonnage, loaded	5,200 tons
Engines, type	Double inclined compound
Engines, H.P.	8,500
Cylinders, 2 H. P.	4 ft. 3 in. × 11 ft.
Cylinders, 2 L. P.	7 ft. 11 in. × 11 ft.
Paddle-wheels, diameter	35 ft.
Boilers, type	Scotch or marine
Boilers, number, 10 H. P.	8,500
Grate area	850 sq. ft.
Heating surface	34,700 sq. ft.
Speed	22 miles per hour

The "Minneapolis."—The cruiser *Minneapolis*, which was illustrated and described in THE AMERICAN ENGINEER AND RAILROAD JOURNAL for September, 1893, has recently had her preliminary trial off the Delaware capes, and her official trial off the coast of Massachusetts. In the first on the offshore run a speed of 21.75 knots was made. The boilers were worked under a forced draft, with anthracite coal burning in the furnaces. From the time of leaving the yards the three engines were run continuously while the cruiser was steaming, and not a flaw of any kind showed itself in her machinery. The *Columbia*, on her preliminary trial trip, showed 20.98 knots, so that the *Minneapolis* showed fully $\frac{3}{4}$ of a knot greater speed. Rough calculations from the indicator cards showed a development of 20,800 H.P., or nearly 3,000 H.P. more than those of the *Columbia* on her official trial trip. On the official trip which was made off the coast of Massachusetts, the engines developed the full 21,000 indicated H.P. called for in the specifications, and developed a speed of 23.05 knots an hour over a course 84 knots in length. The Government boats marking the course were the *Iwana*, *New York*, *Fern*, *Fortune*, *Atlanta*, *Leyden*, *Vesuvius* and *Dolphin*. The time taken at the different stake boats going north was as follows: 22.74 knots, 22.23 knots, 22.75 knots, 22.09 knots, 21.09 knots, 24.05 knots. After a detour of 12 miles made without slowing the engines, the time on the southern trip was as follows: First station, 25.20 knots, 22.40 knots, 24.40 knots, 21.80 knots, 22.86 knots, 22.07 knots, 23.22 knots. The average speed, therefore, on the northern run was 22.90 knots, and on the southern, 23.20 knots, while the average for the entire run of 87.94 knots was 23.05 knots. According to the unofficial reports, the engines developed 21,000 H.P. while running from 130 to 136 revolutions per minute, with an average for the entire course of 134. If the official reports agree with the un-

official figures of the Board, a bonus of $402,500 over and above the contract price will be paid to the builders.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

IX.—METHOD OF DETERMINING TIN IN PHOSPHOR BRONZE.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page* 321.)

OPERATION.

Dissolve 1 gram of fine borings in 20 c.c. of C. P. nitric acid, 1.20 specific gravity, and evaporate at a temperature not exceeding 225° F., until the residue will not adhere to a dry glass rod. Add 15 c.c. of concentrated C. P. nitric acid, 1.42 specific gravity, heat where the temperature is about 275° F. for 10 minutes, add 30 c.c. of distilled water, stir thoroughly, allow to settle a little, and then filter, washing with distilled water, until a drop of the filtrate evaporated on a piece of clean platinum foil leaves no residue. Set the filtrate aside to be used later in the determination of the lead and copper. Put the filter with the hydrated metastannic acid on it back into the same beaker, taking care to spread out the filter, and add 150 c.c of yellow ammonium sulphide. Digest with a cover on the beaker at a temperature of about 212° F. for a couple of hours, with occasional stirring. Nearly all, and in some cases all, the tin dissolves as sulphide, the phosphoric acid goes into solution, while most of the copper, iron, lead, etc., which may be present, remains as sulphides suspended in the liquid. Filter into a beaker holding about 25 fluid ounces, and wash with dilute sulphide of ammonium wash water, and at last with water alone, until the volume of the filtrate and washings amounts to about 250 c.c. Dilute the filtrate and washings with distilled water until the volume is about 400 c.c., and then precipitate the tin sulphide with concentrated C. P. hydrochloric acid, adding it cautiously with stirring, and only adding sufficiently slight excess to react clearly with litmus paper. Cover the beaker and put it where the temperature is about 100° F., and allow to stand one night. Dissolve the sulphides in the filter in dilute nitric acid, and wash thoroughly with water. Add the filtrate to the beaker containing the copper and lead salts. Burn off the filter, ignite at a high temperature in porcelain crucible, weigh and add the weight to the binoxide of tin obtained from the precipitated sulphide. After standing over night, decant the clear liquid above the sulphide of tin through a filter, taking care to get as little as possible of the precipitate on the filter; then add about 150 c.c. of water to the beaker, stir thoroughly, and allow to settle clear. Decant the clear liquid through the same filter, and then add about 150 c.c. of acetate of ammonia water, stir thoroughly, and allow to settle clear and decant as before. Repeat this last operation twice more, provided the second addition of acetate of ammonia wash water settles off clear at once; then pour the precipitate on the filter and wash with the acetate of ammonia wash water until the washings no longer react with nitrate of silver solution. If, after the second addition of acetate of ammonia wash water, the precipitate settles a little slowly, and there is a tendency to a turbid liquid above the precipitate, omit the third addition of acetate of ammonia wash water, and proceed to pour the precipitate on the filter, and finish the washing on the filter as above described. Put the filter and precipitate, still wet, into a porcelain crucible, "smoke off" the filter very slowly, and continue the heating over the burner at low temperature, after the filter has disappeared, until the odor of sulphurous acid is no longer perceptible. Gradually raise the temperature with the burner, finish with an intense heat, and then weigh.

APPARATUS AND REAGENTS.

The apparatus required by this method is simply the ordinary beakers, measuring glasses, etc., common to every laboratory, and requires no special comment.

The nitric acid 1.20 specific gravity is made from the stronger by dilution with water. The dilute nitric acid used to dissolve the sulphides on the filter is a mixture of one part concentrated C. P. with four parts of distilled water.

The yellow ammonium sulphide is made by dissolving 1 oz. of precipitated sulphur in a 5-lb. bottle of what is known in the market as ammonium hydrosulphide, or hydrosulphuret.

The ammonium sulphide wash water is made by adding one part by volume of commercial C. P. ammonium hydrosulphide to nine parts by volume of water.

The acetate of ammonium wash water is made by nearly neutralizing concentrated C. P. acetic acid 1.04 specific gravity with concentrated C. P. ammonia 0.90 specific gravity, and then adding one part by volume of this solution to three parts by volume of distilled water.

CALCULATIONS.

Atomic weights used: Tin, 118; oxygen, 16; molecular formula, SnO_2. Since 78.67 per cent. of the binoxide is metallic tin, the weight found expressed in grams, multiplied by this figure, gives the amount of metallic tin in 1 gram of the bronze. Then the amount in 100 grams, or the per cent., would be found by multiplying this figure by 100. This may be briefly expressed by the rule: Express the weight of binoxide found in grams, move the decimal point two places to the right, and multiply by 0.7867. The product will be the per cent. of tin in the bronze. Thus, if the weight found is 0.1284 gram, the percentage will be [12.84 × 0.7867] 10.10 per cent.

NOTES AND PRECAUTIONS.

It will be observed that this method oxidizes the tin and separates it from the principal portion of the lead, copper, iron, etc., by nitric acid, finishes the separation as completely as ammonium sulphide will do, and removes the phosphoric acid by dissolving the separated metastannic acid in yellow ammonium sulphide, precipitates the tin as sulphide along with much separated sulphur, and converts this sulphide into binoxide for weighing by careful ignition.

The evaporation to dryness needs to be managed with some care. If the temperature is too high, and especially if the action of the heat at high temperature is too prolonged, there will be difficulty with the subsequent solution in ammonium sulphide. On the other hand, if the evaporation to dryness is not carried far enough, the separated metastannic acid is apt to be slimy and give difficulty in the subsequent filtration. A little experience will enable the right point to be reached without difficulty. The treatment of the separated metastannic acid with hydrochloric acid either with or without the addition of potassium chloride to assist the subsequent solution in ammonium sulphide is not necessary if the evaporation to dryness is properly managed, and this procedure introduces complications in the analysis which are better left out.

Fifteen c.c. of concentrated C. P. nitric acid are added to take up the copper and lead salts, after the evaporation to dryness, because approximately this amount of nitric acid is needed in the solution during the subsequent determinations of the lead and copper by electrolysis.

We have not succeeded by any manipulation in completely separating copper and iron from metastannic acid by means of nitric acid, and do not, therefore, recommend ignition and weighing the precipitate obtained after taking up the copper, lead, etc., in strong nitric acid, dilution and filtration.

The digestion of the separated metastannic acid with yellow ammonium sulphide with many bronzes takes up all the tin, so that there is almost nothing left to weigh after dissolving the other sulphides on the filter and ignition of the filter. On the other hand, with some bronzes there is apparently always a little tin left undissolved by the ammonium sulphide. Repeated experiments on a bronze showing this peculiarity gave practically the same results each time, so that it is hardly safe to neglect to follow the directions on this point. The weight of this undissolved tin is rarely more than a milligram.

It is well known that sulphide of copper is slightly soluble in yellow sulphide of ammonium. The sulphide of tin obtained is, therefore, apt to be contaminated slightly with sulphide of copper, and the final weight may also be slightly high on account of oxide of copper.

It is not advisable to leave any of the ammonium sulphide wash water in the filter when washing the sulphides of copper, lead, iron, etc., since this would introduce a little H_2S into the solution in which the copper and lead are to be subsequently determined, an addition which is not desirable. On the other hand, it is not desirable to try to wash copper sulphide from the first with pure water for fear of oxidation and loss.

The precipitation of the tin sulphide is a moderately delicate operation. There must be a slight excess of hydrochloric acid, or tin will remain in solution. On the other hand, if there is too much hydrochloric acid, there is danger of its dis-

solving some of the tin sulphide. Furthermore, the litmus paper test is apt to be affected by the H_2S set free. The litmus paper should not be put into the solution and allowed to remain during the neutralization, as it becomes completely discolored by so doing. Test with a fresh piece each time. After some experience is gained, the way the solution settles off after the last addition of acid is a very good indication of the right point. If the precipitate separates slowly, and the liquid above is inclined to be turbid, either too much or too little acid may be present. If too little, a drop or two more may be just right. If too much, add a few drops of ammonia to alkaline reaction and start again. It is advisable to always test the filtrate from the tin sulphide by adding a few drops of hydrochloric acid, if it is not already clearly acid to test paper, and passing H_2S for half an hour; then allowing the liquid to stand for a couple of hours at a temperature of 120° to 130° F. If no precipitate separates at the end of this time, the filtrate may be thrown away. If any precipitate shows, allow to stand over night, collect on a filter, wash thoroughly, ignite and weigh, adding the weight to the amount previously found.

Allowing the precipitated sulphide to stand in a warm place over night may be unnecessarily long, but as all the constitunts of a phosphor-bronze are usually determined, allowing the tin to stand over night does not usually cause any delay. It seems to be essential to have the H_2S pass off before filtration, since the precipitate is sparingly soluble in solution of sulphuretted hydrogen.

In washing the tin sulphide, it is essential to remove the ammonium chloride completely, or loss of tin will follow during the ignition. By the method of washing recommended, less than 5 per cent. of the total amount of ammonium chloride present remains with the precipitate when it is put on the filter.

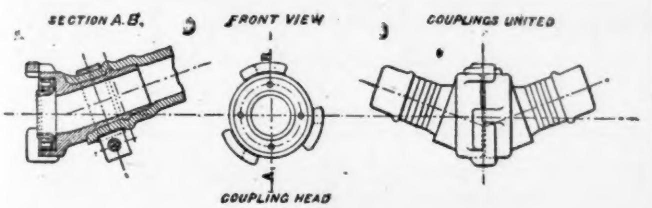


Fig. 1.

It is very difficult to wash tin sulphide mixed with separated sulphur with pure water, on account of the tendency to form a turbid filtrate. As is well known, a slightly acid solution of acetate of ammonia prevents this difficulty. It is advisable, at the very last, to use a much weaker solution of ammonium acetate, so as not to leave too much of this salt with the tin sulphide for fear of reducing some of the tin oxide during the ignition.

The ignition of the wet tin sulphide must be managed with a good deal of caution or there will be either loss of tin sulphide, free sulphur, or sulphuric acid left behind, or some of the oxide of tin reduced. It is believed all these difficulties can be obviated if the ignition is done slowly enough with free access of air. The filter is gotten rid of by "smoking off," which consists in applying the heat to the wet material in the crucible so slowly that the volatile matter of the filter passes off without ignition, free access of air being maintained at the same time. To accomplish this, fold up the wet filter with the tin sulphide in it and place it in the crucible. Put the crucible on the triangle as in ordinary ignitions, and leave the cover off. Then heat the open end of the crucible slowly. The filter and precipitate gradually dry, and soon the parts of the filter in contact with the crucible begin to distill off the volatile matter at low heat, even before the whole is dry. This process goes on if the flame is properly adjusted, until in a little while everything that is volatile at a low temperature has passed away, and the precipitate with a black envelope of carbonaceous matter is left. When this is the case, the temperature can be raised very slowly, the lamp moved back toward the bottom of the crucible a little, and the carbon burned off completely. Many times, when the temperature is raised, the black envelope of carbonaceous matter falls away from the precipitate and is rapidly consumed. The slow heating and free access of air must be continued until the sulphur is all gone. If the heating is done slowly enough, the precipitate is porous, the sulphur apparently all passes away at SO_2, and there is little danger of volatilizing tin sulphide or reducing the oxide.

In bronzes containing perceptible amounts of antimony the tin cannot be successfully determined by the method given above.

TRAIN HEATING WITH STEAM AND COMPRESSED AIR ON THE EASTERN RAILWAY OF FRANCE.

By M. Lancrenon.

Up to a very recent date the Eastern Railway Company, like the other French companies, has used hot water for heating its trains. Recognizing that this system is frequently insufficient and sometimes even troublesome for passengers, especially on night trains with a long run, we have considered for a long time that its simplicity and the ease with which it can be employed in almost all kinds of cars compensated to a great extent for its disadvantages, at least in our climate, and that there was no need for looking for anything else. But this position could not be indefinitely maintained.

As the movement of passengers and the number of trains increase the reheating and manipulation of the cans become more and more difficult, especially at Paris and in the numerous stations from which local trains start. On the other hand, we were compelled, by the necessities of the operating department, to put cars in service that had a communication from end to end, some of which were intended for trains having a long run, others for short-run trains where fares and tickets could be collected *en route*, as well as the double deck cars in the suburban traffic around Paris. The use of the hot-water cans became almost impossible in these different cars, so that it was necessary to get something else.

The long experience which we have had with thermosiphons did not encourage us to develop that system; the German systems were not applicable to our trains, which must be rapidly and frequently made up and broken. Furthermore, they did not keep the feet of the passengers warm—which, in France, is considered to be very necessary. With these conditions in view, we have been led to examine and experiment with a system which is made the subject of this communication.

Principle of the System.—In studying the operation of the German heating apparatus, I have been struck with the difficulty and the slowness with which the heat reaches the end of the train in general working, with a pressure high enough to ensure the efficient penetration of the steam into the heating pipes. In seeking to determine the cause of this phenomena, it occurred to me that it would be possible to obtain a more even pressure in the pipes by adding a fluid—such as air, for example—to the steam, and one which was not susceptible of being condensed. The first experiment was with a crude apparatus set up in the Villette shops, which confirmed the accuracy of my opinion to such an extent that more complete tests were made with an apparatus which was also set up in the shops, and represented a train of 24 cars of four compartments each. The actual cars were intercalated at different points of the circuit. The arrangements which were developed from this examination after several adjustments were then applied to special testing trains, and finally to trains in service. The principal effect of the air which was added to the steam appears to be the sweeping along and continual carriage of the water of the condensation, which tends to accumulate at low points in the pipes, and which might settle at the discharge openings. We have thus avoided losses due to the accumulation of water and the dangers of freezing. The gaseous current, rendered the more intense by the addition of air, by its friction on the liquid molecules causes them to slide along the walls of the pipes. We know that we can thus cause a liquid to pass through a considerable difference in level by using a pressure far less than the height to be raised; and it is upon this principle that the American steam loop is based, which causes, by means of a simple combination of pipes, the water of condensation produced in a pipe fed by a boiler to be carried back to the boiler. This phenomenon can be shown to a certain extent by causing a liquid to move over any surface whatever by simply blowing above it.

Thanks to the addition of the air, the examination of the best methods to be adopted for heating apparatus was singularly simplified and facilitated. It was possible to obtain a discharge of the water of condensation at each car without fear of freezing at the opening; at the same time we thus did away with an obstacle to the introduction of steam into the heating pipes, and reduced the water of condensation to a minimum, as well as compelling it to follow the general conduit to its end. It was thus possible to use heating pipes in these cars that were very much smaller and of a greater variety of forms, without limiting ourselves to maintaining the inclination which would be necessary to the flow of water that depended on gravity alone. It was also possible, in order to facilitate the regulating, to multiply the pipes, and at the same time control

them by simple admission cocks, and bring them together at their extremity at a discharge apparatus without using any arrangements whatever for preventing the return of steam into the pipes which are not in service, the air which is confined in these pipes being sufficient to prevent all heating. From a heating standpoint, the mixture gives practically the same effect as steam when used alone at the same pressure. The quantity of air added and the differences of temperature which resulted therefrom, when taken within the limits employed, are not of such a nature as to modify the calorific effects which are obtained in any appreciable manner.

Description of the Apparatus.—These preliminary matters having been settled, it was easy to settle upon the general details of our apparatus. They comprised a general conduit starting from the engine, into which the engineer could discharge his mixture of air and steam. This conduit extended throughout the whole length of the train and ended in an automatic expansion outlet, which allowed the condensation water and cool air to escape, but stopped the steam. In each car a sufficient number of heating pipes were led off from the general conduit and carried into the compartments, whence they were brought together at their ends and let into a common outlet. The admission cocks let steam into one or all of these pipes at will.

General Conduit and Couplings.—The dimensions of the general conduit were determined after numerous trials, and were made of such a size as to permit of an easy heating of trains of from 15 to 18 cars, and occasionally of 24. Recognizing that it was to our advantage to reduce the diameter at the couplings, we thus obtained the twofold advantage of having the couplings more easily handled, more durable, and of increasing the velocity of the current, so as to avoid as far as possible the accumulation of water and the losses in pressure which would result therefrom. Our conduits, therefore, have an outside diameter of 1¾ in. except at the couplings, where this diameter is reduced to 1⅜ in. The coupling hose is made of rubber, and is fastened to the cars just as the air-brake hose is fastened. The couplings are made by means of flush prongs which clip into each other by a bayonet movement, and which are so designed as to avoid any sudden sagging in the conduit. This design is one for pipes where, as I have already said, a double accumulation of gas and liquid is circulated, the latter sliding along the walls under the entraining action of the current of gases. We have absolutely discarded the German coupling, which was formed of hose independent of the cars, and which is the cause of a great number of inconveniences in the service.

Apparatus on the Engines.—Two arrangements were adopted for the engines. On powerful engines intended for hauling long trains a single pump was found to be insufficient for the brake and the heating service. We have therefore placed a second pump thereon, which was especially intended for the heating, and which discharges into the general conduit both the compressed air and the steam which has served to compress it.

The steam from the boiler thus serves by its expansion to compress the air, and is then utilized for the heating. The speed of the pump in running and its discharge are regulated by means of a steam admission valve. A throttle valve placed directly on the boiler, a safety valve and a steam gauge complete the apparatus on the engine.

On engines which are intended for hauling light trains that consist of not more than 8 or 10 cars, the special heating pump is done away with, and the heating apparatus consists simply of a throttle valve directly on the boiler, an air cock on the pipe opening into a discharge pipe of the air pump for the brake, a safety valve and a steam gauge. In both types the safety valves are set at 17 lbs. per square inch.

Apparatus on the Cars.—The first thing we looked to in the cars was to see that the feet of the passengers should be heated, and then to avoid all contact between the air of the compartments and the pipes directly heated by the steam, so as to prevent the liberation of all odors. In second and third-class cars (fig. 2) the heating pipes, which were three in number, branched out from the general conduit at one end of the car. They first rise vertically to enter into the body of the car, going through the double floor, and then turn horizontally over the top of the floor, passing successively into each compartment under the feet of the passengers. They are covered with ribbed sheets, which are thus heated, and which in turn heat the car.

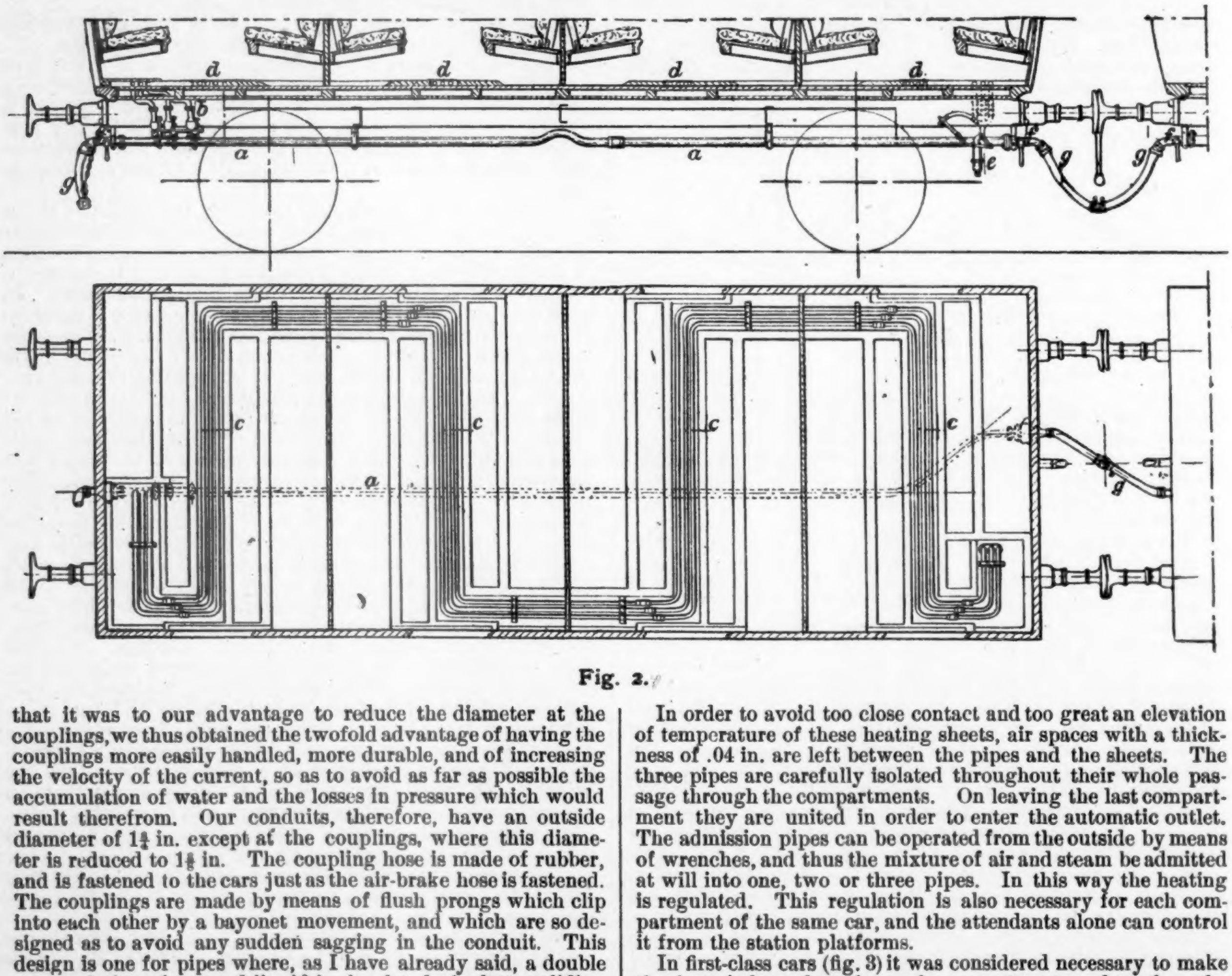


Fig. 2.

In order to avoid too close contact and too great an elevation of temperature of these heating sheets, air spaces with a thickness of .04 in. are left between the pipes and the sheets. The three pipes are carefully isolated throughout their whole passage through the compartments. On leaving the last compartment they are united in order to enter the automatic outlet. The admission pipes can be operated from the outside by means of wrenches, and thus the mixture of air and steam be admitted at will into one, two or three pipes. In this way the heating is regulated. This regulation is also necessary for each compartment of the same car, and the attendants alone can control it from the station platforms.

In first-class cars (fig. 3) it was considered necessary to make the heat independent for each compartment, and to place the regulation at the disposition of the passengers. The arrangement adopted is slightly different from that described. There are two heating pipes for each compartment; they branch out from the general conduit at the right end of the compartment, enter it, pass beneath the feet of the passengers, leave the body to enter a common collector which ends in an automatic outlet. The admission cocks can be controlled from the inside by the passengers or from the outside by the employées. The covering sheet is of brass, and, thanks to its greater conductibility, it gives out the same amount of heat with two pipes as

iron sheets do with three. There is, however, one less degree of regulation possible than in the other cars, but this inferiority is compensated for by placing the regulation at the disposition of the passengers.

The third arrangement, which is entirely different, was adopted for our double-decked cars that are run on the short transit trains in the suburban service of Paris, and is shown in fig. 4. The general conduit of each car is forked, and passes out of the upper story along the side walls. It thus serves as a heating pipe, and heats the wall of this upper story. It is to the others, but is well adapted to the rolling stock to which it is applied. It is not possible to improve it without involving complications and difficulties which are out of all proportions to the object which is sought to be obtained.

Automatic Outlet.—I have only one word to add descriptive of the automatic outlet, which can be placed at the end of the general conduit and on each car. The problem to be solved was to find an apparatus which would only allow the water of condensation in the pipes and the corresponding air to escape, and then close itself as soon as the steam came into contact

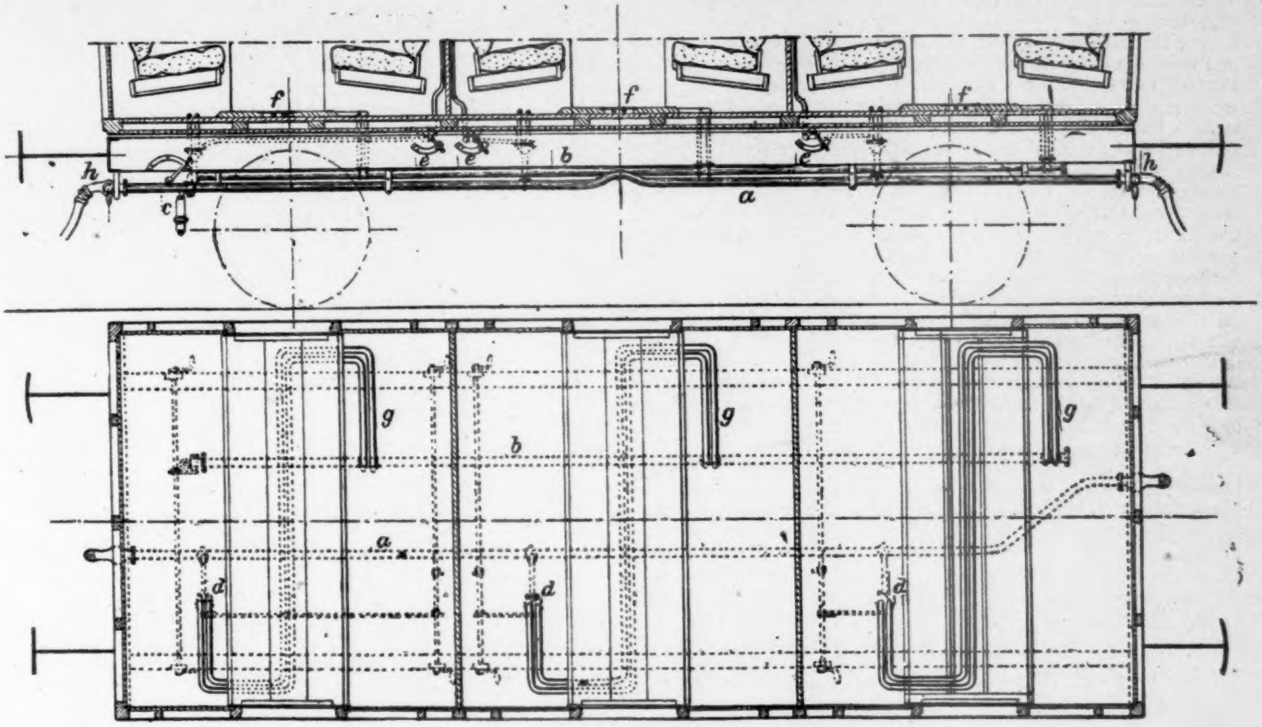


Fig. 3.

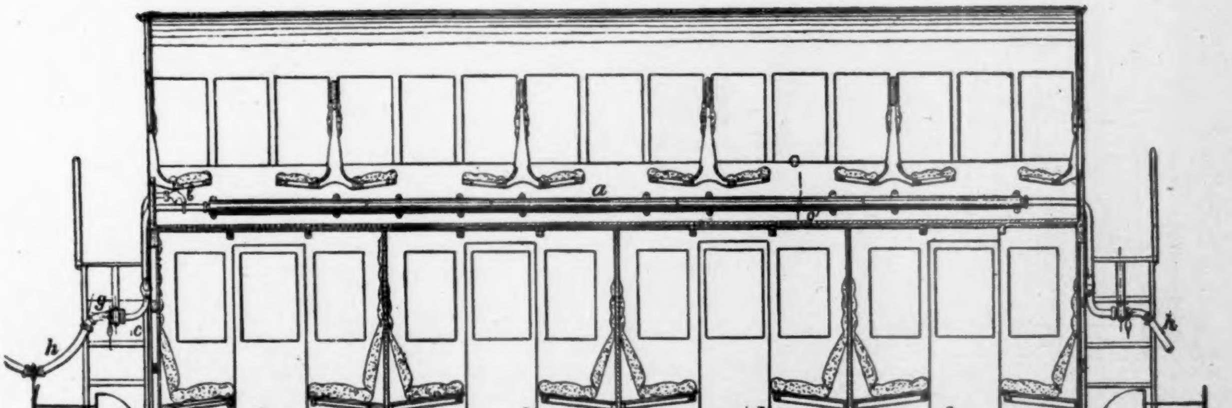
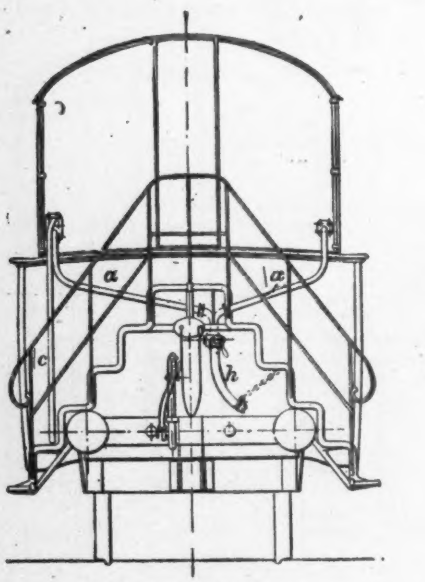


Fig. 4.

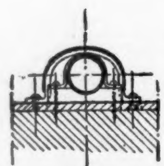
protected by a covering sheet to avoid all danger of burning. A pipe which is controlled at its inlet by a simple stop cock, and which is never closed except in case of breakage, branches off from the general conduit in the upper story and descends to the lower story, where it is divided into two pipes running side by side over the floor and passing successively through all the compartments beneath the feet of the passengers, being finally united again to enter an outlet. No regulation is possible except for the whole of the train, and that is under the control of the engineer, who keeps the heat turned on continually or at intervals; this arrangement is evidently very inferior with it, perfectly regardless of the pressure in the pipes. Such a result can only be obtained by means of an apparatus working by the expansion of a liquid that would give off no vapors at the temperatures under which it worked. The expansions of solids are too slight, and, if they were used, only very slight openings could be obtained, while it might be checked by a single drop of frozen water. With gases and liquids giving off a vapor we would have an apparatus influenced not only by the temperature, but also by the pressure; the liquid must therefore be neutral and unalterable; we have therefore selected oleonaphtha. This liquid is enclosed in a tight metallic cas-

ing that ends in a metallic bellows in the form of a Venetian lantern, which elongates when the liquid expands. The casing is enclosed in another, which is fastened to the ends of the discharge pipes. When steam reaches this envelope the liquid expands, the bellows elongates and closes the opening placed at the end of the same. When, on the other hand, the envelope simply contains air or water, the bellows opens the valve, which then allows this air and water to escape. This apparatus, after frequent attempts and some fruitless trials at the beginning, now works regularly and without danger of freezing even at a temperature as low as from zero to 5° above on the Fahrenheit scale, thanks to the use of compressed air.

Advantages and Disadvantages of the System.—The apparatus I have thus described was put into service during the winter of 1891-92 on the trains running in the suburban service of Paris. The following winter three trains heated in this way were put into service; finally, during this past winter, this system has been put into service on seven trains doing the greater part of the suburban service of Paris on the Avricourt Line, over which 48 trains were run each week day and 54 on Sunday; then on the regular line a large number of night trains, made up of new rolling stock intended for interchange traffic. The necessary apparatus has already been placed on more than 300 cars and on 142 engines. Our experience thus far with these prolonged and somewhat extended tests is such that we may say that the results obtained have always been satisfactory. Our heating sheets have a breadth of about 1 in and a length of 8 ft. 4 in. When the three heating pipes are in use their temperature rises from 140° to 158° F. We consider that this is enough when we take into consideration the dimensions of our compartments and the cold which we have to encounter. It is very evident that this could be raised either by increasing the surface of the sheets and the number of the pipes, or by heating the air of the compartments by pipes placed beneath the seats. From the standpoint of initial heating we have made considerable progress over systems of steam heating by increasing the diameter of the general conduit, and by permitting the air enclosed in the heating pipes to freely escape, and finally by entraining, by means of compressed air, the water of condensation which opposes the flow of the steam.



END VIEW OF FIG. 4.



COVERING OVER STEAM PIPES.

In practice the time required for the steam to reach the end of trains varies as follows: Trains of 12 cars, 8 to 10 minutes; trains of 15 cars, 12 to 16 minutes; trains of 18 cars, 15 to 20 minutes; trains of 24 cars, 28 to 35 minutes. It is necessary to add 5 to 10 minutes to these figures before the heating sheets of the last cars reach a temperature of 130° F. The last figures correspond to the very low outside temperature of from 5° to 15° F. above zero. We thus see that in any case half an hour is sufficient to heat a train of 18 cars.

It is thus possible, without causing any inconvenience whatever, to add one or two cold cars to the end of a train at the last moment, as a very few minutes is sufficient to heat them.

A greater rapidity of operation can be obtained by increasing the diameter of the general conduit, but then the weight of the apparatus raised greater difficulties in making the coupling; but, as a matter of fact, heavy trains are comparatively rare in the winter season, so that we have not found any disadvantages resulting from the diameter of our conduits. The possibility of regulating the heat is as complete as could be desired, for we can not only vary the number of pipes in use, but also interrupt the heating and resume it at will. A very conclusive experiment was made in this in our suburban service during the last winter. At that time the weather remained fine for a long time, but with great variations of temperature. In the morning at sunrise the thermometer

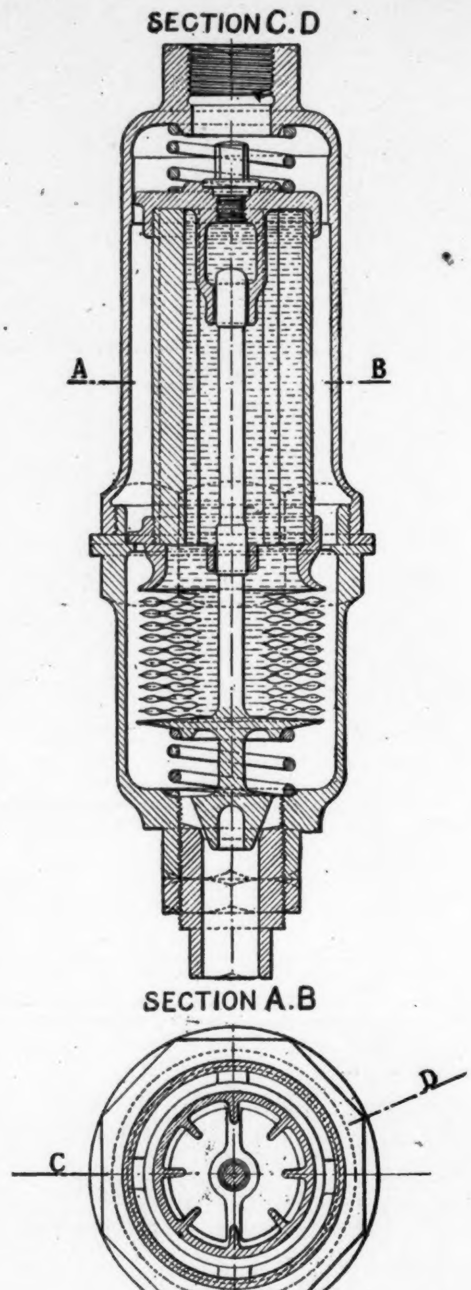


Fig.5

would drop to about freezing-point. We would then heat continuously, and generally with two pipes; then, as the temperature rose, one pipe would be closed. As the thermometer still continued to rise, we would heat the sheets slightly before starting, and then, cutting off the steam, the sheets would remain warm until the end of the trip. If this lasted too long, they would be slightly heated while *en route*. In the middle of the day the heat was entirely cut off; in the evening a reverse practice was followed. In *résumé*, I may state that we can heat our cars when and where we like, and that the em-

ployés can quickly acquire the necessary skill. We have also avoided all danger of fire and all liberation of deleterious gases, as well as the generation of disagreeable odors. In order to obtain this last result it has been necessary to completely isolate the air of the compartments from pipes that are in direct contact with the steam pipes, which have an elevated temperature, and on which any dust that might fall would burn with a characteristic odor; and this is what we have done.

By the arrangement which we have adopted we have been able to comfortably heat the feet of our passengers and then to raise the temperature of our compartments to a moderate degree, and thus maintain a true hygienic condition.

The system has worked for three winters to the entire satisfaction of the operating department. We have had, especially at the beginning, a few disagreeable incidents, some of which —but these were very rare—were due to the inexperience of the employés, others to local defects of the apparatus, which are, of course, unavoidable when an entirely new system is put into service.

The weight of the apparatus averages about 1,100 lbs. per car. This is evidently an increase of dead weight which must be hauled in summer as well as in winter. But it would be difficult to advise anything lighter where a fixed apparatus is used.

The first cost is about $300 per engine for our suburban motive power, which is intended to haul trains of greater or less weight; about $80 for engines intended to haul light trains; from $160 to $180 for second and third-class cars, according to the number of compartments.

The advantages which this system has shown are of such a nature that the Eastern Railway Company has not hesitated to extend its applications to other suburban services in order to increase the comfort of passengers and do away with the trouble arising from the use of hot-water cans.—*Bulletin of International Railway Congress.*

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

THE object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and to help lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a great favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in June, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN JUNE.

Pittston, Pa., June 1.—Ira Gerhardt, an engineer on the Baltimore, Lackawanna & Western Railroad, while leaning out of his cab window, was struck by a post alongside the track at Nay Aug. He was so badly injured that he died shortly afterward.

Miamisburg, O., June 1.—Engineer William Morgan, on the Pittsburgh & Erie Railway, was seriously injured in a head-end collision between a freight and passenger train near here to-day.

Alton, Ill., June 4.—A work train ran into a string of cars three miles east of here to-day, on the St. Louis, Chicago & St. Paul Railway. Engineer Bernard Lynch was killed and Fireman Edward Harrison was seriously injured.

St. Louis, Mo., June 4.—The passenger train on the Mobile & Ohio Railroad was ditched at Fisher's Lake, near Columbia, to-night. The engineer and fireman are reported to be fatally injured.

Philadelphia, Pa., June 4.—Samuel Brown, a fireman on the Philadelphia & Reading Railroad, was killed while attempting to board a moving train this morning. He stumbled and lost hold of the car and fell beneath the wheels. The head was severed from the body.

Hudson, N. Y., June 5.—A wild freight train on the Central Massachusetts Railroad ran into a shifting engine in the Oakdale yard this afternoon. This started the shifter, which ran into another wild freight at Canada Mills, and Engineer Litchman had his leg broken.

Lyons, N. Y., June 5.—Engineer De Wolfe, while leaning out of his cab window, was struck by a mail-pouch catcher. He was knocked senseless, but soon recovered.

Brazil, Ind., June 6.—Engineer William Barr, hauling an extra freight train on the Vandalia Line, was hit by a large stone on the back of his head and killed almost instantly; the stone was thrown by one of a mob of miners.

Knightsville, Ind., June 6.—Strikers stopped a freight train at this point this afternoon, and killed the engineer with stones.

Duluth, Minn., June 7.—A crowd of strikers surrounded a train on the St. Paul & Duluth Railroad and stoned the engineer, injuring him seriously.

Birmingham, Ala., June 7.—A Georgia & Pacific coal train ran into a burning trestle at Patton early this morning. The engine and eight cars pitched into the ravine below. Engineer Goodman had his ankle broken and sustained internal injuries. Fireman Charles Berry was badly cut about the head.

Vancouver, B. C., June 7.—A cloud burst caused a land slide and wrecked a Raymond excursion train to-day. It is reported that both engineer and fireman were killed.

Butler, Mon., June 8.—A passenger train was derailed on the Northern Pacific Railroad just west of here to-day. Engineer Draper was fatally hurt and Fireman Lemin slightly injured.

Denver, Col., June 8.—A passenger train was wrecked in Clear Creek Cañon this morning. John Cooper, the engineer, was injured. The accident was caused by a sunken rail in the road-bed on a sharp curve, throwing part of the train into the water.

Tiffin, O., June 8.—A head-end collision occurred at Republic, on the Baltimore & Ohio Railroad, between two freight trains this morning. One engineer had his foot cut off.

Atlanta, Ga., June 9.—A head-end collision occurred between a passenger and freight train on the Georgia & Pacific Railway, at Greenville, Miss. Engineers Warwick and Dunlap were mortally injured.

Golden, Col., June 8.—A passenger train on the Colorado Central Railroad was wrecked west of this place this morning. At a soft point in the track the rail had sunk, causing a derailment. John Cooper, the engineer of the train, had his back slightly hurt.

Fort Williams, Man., June 9.—A burning bridge gave way under a Canadian & Pacific express train near this point today. Fireman Whitehead and Engineer Elms were injured.

Bellaire, O., June 9.—Miners stoned an engine, hauling a coal train, near Neff's Landing to-day. Charles Bailey, the fireman, was struck on the head and his skull was fractured. Engineer Swarts was also slightly injured.

St. Louis, Mo., June 9.—A fast train on the Vandalia Line was wrecked near Pocahontas, Ill., this morning. Something broke on the forward truck, derailing the train. Fireman S. A. Paulsen was crushed under the tender and killed.

Biddeford, Me., June 10.—A passenger train on the Boston & Maine was wrecked at the station here this morning. The engine tipped over, and Engineer Clarence H. Dodge and Fireman Charles L. Thomas were injured, but not seriously. The cause of the accident was the spreading of the rails.

Owensburg, Ky., June 12.—Train wreckers ditched a train of eight cars from a coal train on the Mississippi Valley Railroad above Central City to-night. Fireman McDowell and the engineer were injured.

Red Bluffs, Cal., June 14.—The logging train belonging to the Sierra Lumber Company jumped from a trestle this morning and plunged down the cañon. The engineer and fireman were injured, but not seriously.

Aurora, Mo., June 15.—A freight train on the Greenfield & Northern Railway was wrecked by tramps, by placing rails on the track 3 miles north of Mt. Vernon this morning. The engineer was badly burned; the fireman was terribly scalded and died in great agony.

New London, Conn., June 17.—J. R. Sperry, an engineer on the Shore Line Railroad, was struck by a switching engine to-night. He was knocked down, and the wheels cut off his left leg at the knee and the toes of his right foot.

Lafayette, Ind., June 20.—A rear-end collision occurred this evening on the main line of the Wabash Road, near this city. It is reported that the engineer and fireman of the colliding train were killed.

Caldwell, O., June 20.—A freight train on the Bellaire, Zanesville & Cincinnati Railway went through a trestle near here to-night. Fireman Allen was instantly killed and Engineer Smith seriously injured.

Knoxville, Tenn., June 20.—A locomotive on the Marietta & North Georgia Railroad exploded its boiler at Hiwassee this afternoon, instantly killing Fireman James Deverais.

Duluth, Minn., June 20.—There was a collision between two trains on the Duluth & Iron Range Railroad at Robinson Lake

LOCOMOTIVE RETURNS FOR THE MONTH OF APRIL, 1894.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage.					Av. Train.		Coal Burned per Mile.						Cost per Locomotive Mile.							Cost per Car Mile.		Cost of Coal per Ton.
			Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Passenger Cars.	Freight Cars.	Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Passenger.	Freight.	
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	850	768	....	....	....	2,007,928	2,614	....	....	....	....	....	84.39	....	....	5.04	7.43	0.21	0.15	6.63	1.42	20.88	....	....	1.69
Canadian Pacific	603	....	472,423	579,990	374,575	1,326,988	2,200	....	....	....	....	....	67.49	....	....	4.73	10.52	0.36	....	5.68	1.51	22.80	....	....	3.08
Chic., Burlington & Quincy	541	....	....	....	....	1,346,782	2,489	4.72	19.74	....	....	....	84.25	....	....	4.10	5.73	0.17	0.19	7.07	0.04	17.30	....	....	1.34
Chic., Milwaukee & St. Paul	855	....	....	....	....	2,279,251	2,665	....	....	....	....	....	71.60	....	....	4.03	6.94	0.26	....	6.94	....	18.17	....	....	2.38
Chic., Rock Island & Pacific	....	564	456,562	841,101	369,312	1,666,975	2,956	....	....	53.16	71.22	40.51	60.80	9.89	4.26	3.03	5.82	0.23	....	6.23	0.40	15.71	....	....	2.02
Chicago & Northwestern	1010	1010	774,207	1,215,204	579,193	2,508.604	2,483	....	....	....	....	....	81.67	....	....	3.68	7.37	0.29	....	6.27	0.91	18.52	....	....	1.79
Cincinnati Southern	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cumberland & Penn.*	23	23	5,084	31,218	....	36,302	1,578	....	....	....	....	....	84.39	....	....	5.47	4.60	0.34	....	....	1.74	12.15	....	....	....
Delaware, Lackawanna & W. Main L.	213	176	70,285	196,970	322,063	589,318	3.348	....	....	....	....	....	87.45	....	....	2.88	6.74	0.41	....	6.22	....	16.25	....	....	1.55
Morris & Essex Division	162	....	173,791	146,104	88,328	408,223	2,519	....	....	....	....	....	65.23	....	....	3.59	10.22	0.37	....	6.72	....	20.90	....	....	3.10
Flint & Père Marquette	....	....	83,767	71,051	61,149	215,967	2,769	....	....	51.29	83.33	....	67.31	....	....	3.38	6.47	1.63	....	5.18	0.88	16.06	....	....	1.78
Hannibal & St. Joseph	67	67	....	....	....	231,706	3,565	4.84	17.29	....	....	....	81.72	14.55	6.14	1.49	5.47	0.09	0.15	6.41	0.02	13.63	....	....	1.37
Kansas City, Ft. S. & Memphis	149	....	90,979	190,074	83,811	364,864	2,785	....	....	....	....	....	67.84	....	....	2.83	5.01	0.23	0.44	7.39	....	15.90	....	....	1.45
Kan. City, Mem. & Birm	42	38	33,361	50,308	11,818	95,487	2,513	....	....	....	....	....	62.28	....	....	3.36	3.55	0.24	0.26	6.99	....	14.40	....	....	1.06
Kan. City, St. Jo. & Council Bluffs	36	36	....	....	....	129,325	3,592	5.03	22.84	....	....	....	72.78	14.77	4.51	3.62	6.82	0.16	0.39	6.56	0.04	17.59	....	....	1.91
Lake Shore & Mich. Southern	595	....	407,966	738,629	376,148	1,522,743	2,922	....	....	58.92	88.38	37.61	67.91	....	....	2.98	4.68	0.05	0.12	6.77	0.16	14.76	....	....	1.37
Louisville & Nashville	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Manhattan Elevated	....	293	748,173	....	66,571	814,684	2,780	....	....	....	....	....	39.67	....	....	2.00	8.00	0.20	....	9.00	....	19.20	....	....	4.04
Mexican Central	148	128	....	....	....	421,772	....	....	....	....	....	....	68.72	....	....	5.24	12.90	0.41	0.08	4.52	....	23.15	....	....	4.03
Minn., St. Paul & Sault Ste. Marie	104	79	77,860	107,705	25,139	210,704	2,667	4.97	21.34	....	....	....	67.20	....	4.66	4.65	10 86	0.24	....	6.63	....	22.38	3.52	1.27	3.20
Missouri Pacific	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Mobile & Ohio	107	84	75,171	152,767	52,242	280,180	3,334	....	....	....	....	....	62.87	....	....	2.49	4.53	0.20	0.63	5.72	0.96	14.53	....	....	1.43
N. O. and Northeastern	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
N. Y., Lake Erie & Western	634	382	417,758	695,312	231,094	1,344,164	3,519	4.30	24.60	91.10	134.90	82.00	102.66	21.10	5.50	4.14	7.65	0.36	2.09	7.36	1.29	22.89	....	....	1.39
N. Y., N. H. & H., Old Colony Div	....	....	462,812	196,252	219,611	878,675	....	4.00	17.50	....	....	....	66.11	....	....	3.06	9.93	0.56	....	7.25	0.76	21.56	17.00	5.40	....
N. Y., Pennsylvania & Ohio	276	152	122,551	326,585	117,270	566,406	3,726	5.30	19.70	70.60	131.50	99.90	97.66	13.20	6.70	3.49	5.51	0.30	1.99	7.02	1.17	19.48	....	....	1.00
Norfolk & Western, Gen. East. Div.†	....	....	92,158	283,313	49,307	424,778	2,622	4.81	21.08	46.20	132.80	....	....	9.60	6.30	6.40	3.75	0.28	....	....	....	10.43	....	....	....
General Western Division†	....	....	95,231	327,469	60,056	482,756	2,823	5.51	17.46	77.00	137.00	107.00	121.00	13.87	7.88	9.59	4.14	0.26	....	....	....	13.99	....	....	....
Ohio and Mississippi	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Philadelphia & Reading	....	....	408,104	302,013	705,766	1,415,883	....	....	....	....	....	....	81.97	....	....	4.54	4.86	0.25	....	5.74	0.48	15.87	....	....	....
Southern Pacific, Pacific System	725	639	690,942	775,768	267,216	1,733,926	2,713	5.75	14.44	....	....	....	67.07	....	....	6.41	17.41	0.21	1.98	7.22	1.10	34.33	....	....	4.87
Union Pacific	865	....	484,195	850,398	323,536	1,659,129	3,114	6.16	18.25	....	....	....	98.86	13.33	7.66	10.29	10.50	0.40	....	8.45	1.33	30.97	4.68	2.25	2.36
Wabash	418	327	411,714	549,086	190,765	1,151,565	3,521	4.58	16.93	63.59	104.98	60.96	83.33	13.33	6.20	3.49	4.47	0.26	....	6.05	0.93	15.20	2.95	1.01	1.07
Wisconsin Central	149	99	124,884	133,523	48,369	306,776	3,098	....	....	....	....	....	72.27	....	....	2.75	7.32	0.15	....	7.05	....	17.23	....	....	2.00

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars. Empty cars which are reckoned as one loaded car are not given upon all of the official reports, from which the above table is compiled. The Union and Southern Pacific, and New York, New Haven & Hartford rate two empties as one loaded; the Kansas City, St. Joseph & Council Bluffs and Hannibal & St. Joseph Railroads rate three empties as two loaded; and the Missouri Pacific and the Wabash Railroads rate five empties as three loaded, so the average may be taken as practically two empties to one loaded

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

last night. Engineer Oscar Norlander was injured, suffering a contusion of the spine.

Lafayette, Ind., June 21.—A collision between Wabash freight trains occurred near this point. Engineer J. G. Storze was seriously injured.

Augusta, Ga., June 21.—Train wreckers broke a lock on the switch station of an old siding near Millen this morning, and placed ties upon the track. After opening the switch, a mixed train ran into it and was wrecked. Engineer Clem Starr and Fireman Jasper Robner jumped, but were caught in the wreck. Engineer Starr had his right leg broken and thigh fractured. He was also internally injured, and there is no hope of his recovery. The fireman escaped with a sprained ankle.

Paterson, N. J., June 22.—Engineer Floyd Pollison, hauling a fast train on the New York, Susquehanna & Western Railroad, while leaning out from the tender, trying to detect some fault with his air brakes, was struck by a signal pole and severely injured, but not fatally.

Denver, Col., June 25.—John P. Finch, an engineer on the Burlington & Missouri Railroad, fell from his engine this afternoon. His skull was fractured and his face mangled beyond recognition. The engine was moving at the rate of 20 miles an hour at the time, and he was dead when his body was picked up.

Galena, Ill., June 28.—A fireman on the Chicago, Burlington & Quincy Railroad was seriously burned this morning by the bursting of a lubricator glass which allowed the oil to flow down over the boiler head. Martin's clothes, which were saturated with oil, caught fire, and he was soon enveloped in flames.

Chicago, Ill., June 28.—Herbert Van Avery, an engineer on the Chicago & Northwestern Railroad, was fatally injured by being struck by a piece of cylinder-head that blew out this morning.

Reading, Pa., June 28.—A passenger train on the Pennsylvania Railroad ran into the rear end of a freight train 2 miles north of this city this morning. James Murray, fireman of the passenger train, jumped, and was instantly killed.

Louisville, Ky., June 28.—A freight train on the Kansas City, Memphis & Birmingham Road jumped the track near Horse Creek to-day and was wrecked. Engineer Bois Clair escaped by jumping, but was internally injured. The fireman, Jack Hale, was caught under the locomotive and scalded and crushed to death.

Wheeling, W. Va., June 28.—Otto Bowers, a locomotive fireman on the Baltimore & Ohio Railroad, was thrown under the wheels and crushed to death while jumping from his engine this afternoon.

Chicago, Ill., June 29.—Spikes were driven into a switch and along the Chicago & Alton tracks near Sixteenth Street this morning; an engine pulling a freight train was derailed and thrown on its side. The engineer and fireman escaped with bruises.

Our report for June, it will be seen, includes 39 accidents, in which 14 engineers and 12 firemen were killed, and 20 engineers and 10 firemen were injured. The causes of the accidents may be classified as follows:

Boarding train in motion	1
Boiler explosion	1
Broken truck	1
Bursting lubricator glass	1
Collisions	9
Defective bridge	3
Derailments	6
Falling from engine	2
Landslide	1
Rails spreading	1
Strikers	4
Struck by cylinder-head	1
" " engine	1
" " obstruction	3
Train wreckers	4
Total	39

PROCEEDINGS OF SOCIETIES.

Engineers' Club, Philadelphia.—At the meeting of June 16, Mr. Benjamin Franklin read a discussion on Mr. Schermerhorn's paper on the Improvement of the Delaware River at Philadelphia. He disagreed with Mr. Schermerhorn's conclusions to the effect that, as the Delaware River is not a silt-bearing stream, properly located, artificial channels would remain of permanent depth, and argued that permanency of result could best be obtained by regulating works, and that no dependence can be placed upon dredging without such auxiliary structures.

Association of Engineers of Virginia.—At a recent meeting M. Rene de Saussure presented a paper on the Reproduction of Color by Photography. In describing the process, he stated that the only difference between this and the ordinary process was, that ordinarily used is the finer preparation of the plates and the introduction of a mirror immediately behind the plate. The principles involved are the relative lengths of the waves of light for the different colors and the interference produced by the reflective rays acting with the direct rays of light. The process is a very fine demonstration of the correctness of the wave theory of light, as the whole process is worked out on that theory as a basis. The one drawback to the colored photographs coming into common use is the fact that the plates have to be extra fine and sensitive, and have to be used within a day or two after they have been prepared, and so cannot be put upon the market for sale until improvements are made which will overcome this difficulty.

Master Car Builders' Association.—The Secretary has issued a circular relating to letter ballots that include the recommendation of the committees reporting at the last convention. A reference to our issue for July will give an idea of the scope of the recommendations, the first of which relates to the size of catalogues, specifications, etc.; the second is on wheel and flange gauges, which includes the following definitions:

1. Track Rails are the two main rails forming the track.
2. Gauge of Track is the shortest distance between the heads of the track rails.
3. Base Line, for wheel gauges, is a line parallel to the axis of the wheels, drawn through the point of intersection of tread, with a line perpendicular to the axis and passing through the center of the throat curve.
4. Inside Gauge of Flanges is the distance between backs of flanges of a pair of mounted wheels measured on a line parallel to the base line, but ¼ in. nearer to the axis of the wheels.
5. Gauge of Wheels is the distance between outside faces of flanges of a pair of mounted wheels measured on a line parallel to the base line, but 11/16 in. further from the axis of the wheels.
6. Thickness of Flange is the distance measured parallel to the base line between two lines perpendicular thereto, one drawn through the point of measurement of "inside gauge of flanges," and the other drawn through the point of measurement of "gauge of wheels."
7. Width of Tread is the distance measured parallel to the base line from a line perpendicular thereto, one drawn through the point of measurement of "gauge of wheels" to the outer edge of the tread.
8. Check Gauge Distance is the distance measured parallel to the base line between two lines perpendicular thereto, one drawn through the point of measurement of inside gauge of flanges " on either wheel, and the other drawn through point of measurement of" gauge of wheels on mate wheel.
9. Over-All Gauge is the distance parallel to the base line from outer edge of one wheel to the outer edge of mate wheel.

Note.—It should be understood, from the above definitions, that if the M. C. B. standards already adopted are taken, the above-mentioned wheel gauge will be directly, or by inference, as follows:

Inside gauge of flanges	4 ft.	5⅜ in.
Gauge of wheels	4 "	8⅛ "
Thickness of flange		1⅜ "
Width of tread		4⅛ "
Check of gauge distance	4 "	6¾ "
Over-all gauge	5 "	4⅜ "

The third is regarding the height of brake beams, which is placed at 13 in. to the center of new shoes above the rail for inside hung beams and 14½ in. for outside hung beams. Fourth, steel-tired wheels and their limit of thickness of tires, which should not be less than 1 in. above the tread and the throat of the flange. Fifth, safety chains. Sixth, lubrication of cars, in which an improvement is made in the design of the journal bearing and wedge by rounding the top of the latter instead of the top of the bearing. Seventh, regarding a set of journal-bearing and wedge gauges. Eighth, a modification of the dummy coupling hook. Ninth, a defect card for air brakes. Tenth, freight car trucks. Eleventh, ladders; in the latter case it is claimed that the distance of 3¼ in. which the round stands from the car is sufficient to allow the feet to slip through, and that 2¼ in. instead of 3¼ in. should be made the standard.

INTERNATIONAL RAILWAY CONGRESS.

THE fifth session of the International Congress of Railways will be held in London in June, 1895, as announced in our issue for June. The programme of papers has now been published, and is divided into five sections. The first section is on track and permanent way.

I. *Strengthening of Track with a View of Increasing the Speed of Trains.*—Model of tracks to be adopted for lines traversed by high-speed trains. Small increase of strength of existing tracks, so as to admit of an increase in the speed of trains :

A. Outline of rail. Determination of dynamic strains to be carried. Results of experiments.

B. Conditions of manufacturing and nature of the metal of rails. Comparison of soft with hard steel. Steel product : by the special process with the Bessemer converter ; by the basic process with the converter ; by both processes with the Martin furnace.

C. Rail connections. Strain carried by rail joints. Construction of the joint which will assure the most uniform resistance of the track at all points ; double-headed and Vignole rails.

D. Quality, dimensions, spacing.

E. Ballast : kind, method of placing. The committee to report on this is composed of M. W. Ast, Consulting Engineer to the Regency and Director of Track and Permanent Way of the railway of the North Emperor Ferdinand, of Austria, 50 Nordbahnstrasse, Vienna ; and Mr. Hunt, Engineer of Track of the Lancashire & Yorkshire Railway, Manchester, England.

II. *Special Points on the Track.*—Means used to do away with the slowing down of fast trains and avoiding shocks of passing special points on the tracks, such as curves of short radius, long grades, point switches, crossings, grade crossings, turn-tables, etc. This matter is in charge of M. Sabouret, Engineer of Bridges and Highways, Chief Engineer of Central Service of the Paris & Orleans Railway, 1 Valhubert Place, Paris.

III. *Junction Points.*—The most favorable conditions of the construction of junction points on tracks where high-speed trains are run, with a view of entirely doing away with slowing down. Best arrangements to adopt for points and ties. Best means to maintain speed of trains by doing away with the superelevation of the rail on curves at junction points. A. Zanotta, Chief Engineer of the Department of Maintenance Inspection, and Director of the Mediterranean Railway of Italy, Milan.

IV. *Construction and Testing of Metallic Bridges.*—*A.* What are the qualities of metal used and to be used in railway bridges, taking into account the specifications in vogue in different countries ?

B. What is the nature and value of the different methods used by various railway companies for periodical testing of metallic bridges ? What is the actual importance which can be given to these tests, and can they be regarded as an experimental means of establishing the effective conditions of solidity and the degree of safety on the said constructions ? Max Edler von Leber, Chief Inspector of corps I. and R. of the General Inspection Department of the Eastern Railways to the Minister I. and R. of Commerce, Vienna.

SECTION II.—LOCOMOTIVES AND CARS.

V. *Boilers, Fire-boxes and Tubes of Locomotives.*—*A.* Steel boilers in fire-boxes. Strains carried in service and conditions of acceptance of sheets.

B. Iron tubes. Means of avoiding cracks in tube sheets.

C. Injurious action exerted by the feed-water upon boilers and tubes. Systems of purification.

D. Programme of tests relative to the production of steam, to wit : Results given by tubes according to their diameter, their length, the system, their arrangement in the boiler and the metal of which they are made ; tests on the influence of the size of the smoke-box and different forms of stacks and spark arresters ; tests on the different systems of exhaust ; tests on the influence which speed may have on production of steam. Eduard Sauvage, Engineer of Material and Rolling Stock of the Eastern Railways of France, 168 Rue de Lafayette, Paris.

VI. *Locomotives for High-speed Trains.*—Type of engine best suited for high speed. Use of high pressures and the application of the compound principle. Improved method of distribution and balanced valve. Conditions of construction of locomotives, with a view to decreasing the dynamic strains exerted upon the track. Influence from the latter standpoint of the compound arrangement. Mr. Aspinwall, Chief Mechanical Engineer of the Lancashire & Yorkshire Railway, Horwich, England.

VII. *Cars for High-speed Trains.*—Type of cars for high-speed trains and for long runs. Flexibility and condition of train. Improvements made in the interior arrangement. Various methods of heating and lighting. Mr. Park, Carriage Superintendent of the London & Northwestern Railway, Ruelburton, England.

VIII. *Electric Traction.*—General system of electric traction. M. Auvert, Engineer of the Central Service of Material Department of the Paris, Lyons & Mediterranean Railway, Boulevard Diderot, Paris.

SECTION III.—TRANSPORTATION DEPARTMENT.

IX. *Acceleration of the Transportation of Merchandise.*—The influence of speed of transportation on the expense of traction and the utilization of railway stock on one hand, and on the efficiency of the rolling stock and the development of fixed installations on the other hand. Mr. Lambert, General Manager of the Great Western Railway, Paddington, London, W., England.

X. *Switching at Stations.*—*A.* Means of accelerating switching movements and the handling of merchandise. Arrangement of stations at starting-points. Mr. J. Richter, Director of the line from St. Petersburg to Varsouvia, of the Russian State Railway, Varsouvia Station, St. Petersburg, and Mr. Turner, General Manager of the Midland Railway, Derby, England.

B. Use of mechanical and electrical methods for accelerating the handling of merchandise and switching operations. Messrs. Eugene Sartiaux, Chief Electrician of the Northern Railway of France, 95 Rue de Mandenge, Paris ; and A. des Boschan, Engineer of the North Emperor Ferdinand of the Austria Railway, 50 Nordbahnstrasse, Vienna ; and M. Turner, General Manager of the Midland Railway, Derby, England.

XI. *Signals.*—Recent improvements in the block signaling apparatus, especially from the standpoint of saving of installation. Signals in tunnels. Means used to avoid collisions at dangerous points of high-speed lines in case of the breaking down of the stopping signals. Substitution of the language of colors by geometrical forms, with a view of avoiding the dangers resulting from color blindness or defects of vision. Messrs. Lucien Motte, Engineer of Track and Permanent Way of the Belgian State Railway, at Namur ; and Thompson, Signal Superintendent of the London & Northwestern Railway at Crewe, England.

XII. *Porterage and Tracking.*—Organization of trucking service for gathering in and delivery of goods from a private warehouse in connection with railway service. Mr. Twelvetrees, Chief Goods Manager of the Great Northern Railway, Kings Cross, London N., England.

SECTION IV.—GENERAL ORDER.

XIII. *Organization of Service of Central Administration on the Different Roads of Different Countries.*—Messrs. Ducker, Director General of the Roumania State Railway, and Professor in School of Bridges and Highways at Bucharest, Roumania, and Harrison, General Manager of the London & Northwestern Railway, Euston, London, N. W.

XIV. *Regulation of Lawsuits.*—The regulation of lawsuits which occur in the different railways having interchange relations. M. Dupeil, Director of the Russian Union of the International Relation of Railways, Italians Kaia, St. Petersburg.

XV. *Twenty-four-Hour Dials.*—Introduction of continuous points of enumeration from 1 to 24, and the division of the hour into 100 parts. Condition of the question. Partial application in different countries. Advantages to the public and to the service. The modifications of the dials of clocks that would be necessary, and how would it act in the affirmative ? M. Leon Scolari, Chief Inspector of the Mediterranean Railway, Italy, and Joseph Rocca, Inspector of the same road, at Milan.

XVI. *Decimal System.*—Generalization of the decimal system in calculations relative to construction and the management of railways. Means of facilitating the introduction of the metric system of weights and measures in countries where it is not in use. Mr. Wilkinson, Chief Goods Manager of the Great Western Railway, Paddington, London, W.

SECTION V.—ECONOMICAL RAILWAYS.

XVII. *Feeding Railways.*—*A.* Means used by the management of great lines to facilitate the building and operation of chief feeding lines. H. Debacker, Director-General of the Society of Economical Railways of Belgium, 52 Rue de Armour, Brussels, Belgium.

B. Facilities which can be guaranteed by the governmental authorities to favor the construction and operation of railways of light traffic, without injuring them in any way from the

standpoint of safety. A. C. Humphreys Owen, Member of the English Parliament, Administrator of the Cambrian Railways; and P. W. Meik, Member of the Institution of Civil Engineers of England.

XVIII. *Leases of the Operation of Chief Railways.*—What are the countries where leases have been applied? What are the conditions to which they have been applied, and what are the useful results which have been obtained therefrom? M. Du Burlet, General Manager of the National Belgium Railway, Société Nationale Belge des Chemins de Fer, Vicinaux, 26 Rue du Science, Brussels; and C. Colson, Engineer of Bridges and Highways, 50 Rue de Rennes, Paris.

XIX. *Depots of Chief Railways.*—Is it best to furnish the name of the depot at the center or at one end of the line? M. Terzi, Director of the Suzzara-Verrara, at Sermide, Italy.

XX. *Brakes of Different Railways.*—Study of the various systems of brakes applied to different railways. Technical conditions and conditions of safety. M. Ploq, Engineering Chief of the Operating Department of the Société Génerale des Chemins de Fer, Économique, at Arras.

ANNEX.

Technical reports to be gathered in conformity with the formulæ adopted by the congress on first section tracks and permanent structures.

A. Breakage of steel rails, by Mr. Bricker, Engineer of Track and Buildings of the State Railway of France, 136 Boulevard Raspail, Paris.

B. Cost of maintenance of metallic ties in comparison with those of wooden ties by M. Kowalski, Engineer of the Bone-Guelma Railway, Rue des D'Aslorg, Paris.

C. Operation of wooden ties of different kinds not injected, or injected according to different processes, by B. Hezenstein, Vice-President of the Commission on the Examination for the Preservation of Wood, 22 Nevsky Prospect, St. Petersburg.

SECTION II.—LOCOMOTIVES AND ROLLING STOCK.

D. Bent axles on locomotives, by M. Hodeige, Chief Engineer of the Belgium State Railways, 10 Rue des Cale.

E. Locomotive fire-boxes, by M. Hodeige, Chief Engineer of the Belgium State Railways, 10 Rue des Cale.

F. Locomotive boilers, by M. Beleroche, Chief Engineer of the Central Railway of Belgium, 76 Rue Belliard, Brussels.

G. Lubrication of cars, by M. Hubert, Chief Engineer of the Belgium State Railways, 19 Rue de la Loi, Brussels.

H. Switching engines, by M. Hodeige.

SECTION IV.—GENERAL ORDER.

I. Movement of *personnel* in different countries, by G. du Labeleye, Member of the Congress of Administration of the Congo Railway, 21 Place Louvain, Brussels.

Recent Inventions.

DE LAVAL'S STEAM TURBINE.

ONE of the exhibits at Chicago last summer which attracted perhaps as much or more attention from mechanical engineers than any other was the steam turbine which is the invention of Carl Gustav Patrik De Laval, of Stockholm, Sweden. This invention is very fully and clearly described in his American patent, which has recently been issued, and which we republish, almost entire, with the engravings—figs. 1 and 2—which are appended to it. In these specifications the inventor says:

"Heretofore in steam turbines, as well as in other steam-engines, the energy contained in the steam has been utilized in the form of pressure and the steam has performed its mechanical work during its expansion. According to my invention the steam is expanded in a nozzle or conduit of peculiar construction before it acts upon the turbine or bucket wheel. During this expansion of the steam in the nozzle or conduit the pressure of the steam is converted into velocity, and the energy contained in the steam is made use of after it leaves the nozzle or conduit in the form of its *vis viva*. The steam reaches the wheel in this expanded condition and rotates the wheel by its *vis viva*, while heretofore the steam was expanded within or against the turbine wheel or other movable part, which was so actuated by the pressure of the expanding steam.

"In the accompanying drawings fig. 1 is a front view of my improved steam engine, partly in section; fig. 2 is a fragmentary side view of the same, also partly in section.

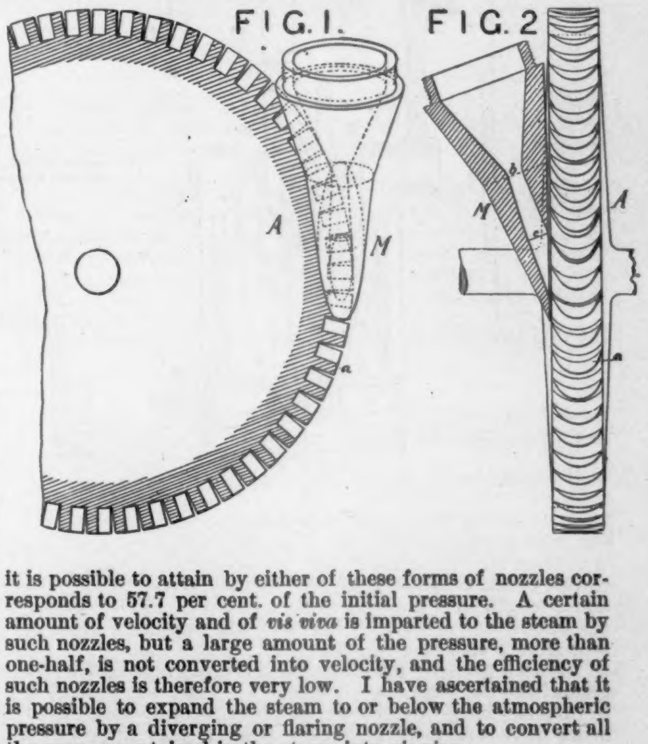
"Like letters of reference refer to like parts in both figures.

"*A* represents a turbine wheel provided at its face with buckets *a*.

"*M* represents the steam nozzle which is fitted with its discharge end against one side of the wheel, so as to direct the current of steam against the buckets thereof. This nozzle has its receiving end connected with a steam-pipe or other steam supply which furnishes steam to the nozzle under a suitable pressure. The nozzle may be contracted from its receiving end to its narrowest portion *b*, which has the proper area to deliver the volume of steam which is required for performing the work for which the engine is designed. The nozzle is diverging or gradually enlarged in cross-section from this narrowest point to its discharge opening *c*, by which the steam is delivered against the buckets of the wheel. The axis of the nozzle is arranged at an acute angle to the plane of the wheel, and the end of the nozzle is arranged parallel with the side of the wheel, so as to fit as closely as possible against the same. This renders the diverging portion of the nozzle shortest at the point where the revolving buckets first reach the nozzle, and longest at the point where the buckets leave the nozzle.

"The buckets of the wheel are concavo-convex and arranged with the convex side forwardly, so that the side portion of each bucket which is adjacent to the steam nozzle stands about in line with the axis of the nozzle in passing by the latter, while the opposite side portion of the bucket stands about at right angles to the axis of the nozzle. This permits the steam current to enter between the buckets on the receiving side of the wheel with very little resistance.

"Scientific researches made by other investigators, as well as my own, have shown that when steam issues from a cylindrical or converging nozzle, the maximum of expansion which



it is possible to attain by either of these forms of nozzles corresponds to 57.7 per cent. of the initial pressure. A certain amount of velocity and of *vis viva* is imparted to the steam by such nozzles, but a large amount of the pressure, more than one-half, is not converted into velocity, and the efficiency of such nozzles is therefore very low. I have ascertained that it is possible to expand the steam to or below the atmospheric pressure by a diverging or flaring nozzle, and to convert all the energy contained in the steam into *vis viva*.

"In my improved nozzle, as shown in the drawings, the converging portion of the nozzle serves principally to reduce the cross-section of the outlet to that area which will emit the necessary quantity of steam. In engines of ordinary size, this area of the narrowest portion of the nozzle is so small that the steam supply pipe has to be much larger in diameter in order to render its connection with other fittings convenient and to avoid excessive friction in the pipe, but while the converging portion of the nozzle is therefore desirable, it is not indispensable.

"The steam current, when leaving the narrowest part of the discharge nozzle, has reached the maximum of expansion which is possible in a straight or contracted nozzle, and the pressure under this degree of expansion is equal to 57.7 per cent. of the initial pressure. In the diverging nozzle, the pressure is still further reduced by expansion and the speed of the current is correspondingly increased so that, at the discharge end of the diverging nozzle, the pressure has nearly dropped to that of the atmosphere or to that of the fluid or medium into which the nozzle discharges, and practically all

the pressure of the steam has been converted into velocity. In other words, the 57.7 per cent. of the initial pressure, which existed in the steam current at the throat or narrowest point of the nozzle, is converted into velocity by expansion in the diverging nozzle.

"The diverging nozzle is so proportioned that the speed of the steam increases as it passes through the nozzle. In order to attain this result the divergency of the nozzle should be such that the areas of succeeding cross-sections of the nozzle increase in a lesser degree than the volume of the steam from cross-section to cross-section. The speed of the steam at each given cross-section of the nozzle depends upon the proportion between the passing volume of the steam and the area of the cross-section, and under the proportion stated the volume of the steam in passing through the diverging nozzle increases in greater proportion than the areas of the cross-sections of the nozzles, whereby the velocity of the steam is correspondingly increased.

"As an illustration it may be stated that a nozzle in which the diverging portion has a diameter of $\frac{1}{8}$ of an inch at its narrowest point, a diameter of $\frac{3}{8}$ of an inch at its discharge end, and a length of 3 in., will expand steam of 165 lbs. pressure per square inch down to 3 lbs., and will produce a steam current of corresponding velocity.

"With a properly proportioned diverging nozzle, the steam issues from the nozzle in a compact jet, which has no tendency to further expand or change its pressure or specific gravity, hence there is no tendency for the steam to leak at the sides of the wheel, but the entire jet is bodily thrown against the wheel and made effective in actuating the same.

"The steam current issuing from the nozzle with little or no pressure, but great velocity, strikes the buckets of the wheel and revolves the latter at an exceedingly high rate of speed, in many cases higher than 15,000 revolutions per minute. The practically complete conversion of the pressure of the steam into velocity and the utilization of the *vis viva* of the swiftly moving current of steam renders this engine very economical in the consumption of steam while its construction is exceedingly simple.

"From what has been said, it is evident that all necessity of tightening against steam pressure ceases at the end of the nozzle. In this consists one of the advantages of my steam turbine above all other constructions where steam is admitted to the turbine under pressure, and consequently leaks out at all sides instead of passing through the turbine wheel. The live steam does not come in contact with any of the working parts of the turbine, and the machine therefore works equally well with superheated as with saturated steam. Here is also an opportunity for economizing heat, which is impossible in ordinary steam-engines on account of the sensitiveness of the packing boxes to heat.

"The economy of this turbine has been established by numerous trials. For instance, with a 50-H.P. turbine dynamo an effect of 63.7 H.P. was obtained with a consumption of 19.73 lbs. of steam and 2.67 lbs. of coal per hour and H.P.

"I am aware that in Williams on 'Heat in its Relations to Water and Steam,' pp. 235-44, a theory is set forth which apparently does not agree with that set forth in the foregoing description, but whether this disagreement be real or only apparent, the fact is that the statements contained herein are correct and based upon many carefully conducted trials of steam turbines provided with the various nozzles referred to, which trials have extended over a considerable period of time and were made under widely different pressures.

"I claim as my invention—

"1. The combination with a bucket or turbine wheel, of a stationary nozzle opening adjacent to the wheel and having its bore diverging or increasing in area of cross-section toward its discharge end, whereby the elastic fluid under pressure is expanded in passing through the diverging nozzle and its pressure is converted into velocity before the jet is delivered against the wheel, substantially as set forth.

"2. The combination with a bucket or turbine wheel, of a stationary nozzle opening adjacent to the wheel and provided with a contracted receiving portion and with a discharge portion having its bore diverging or increasing in area or cross-section toward its discharge end, substantially as set forth.

"3. The combination with a turbine wheel provided with concavo-convex buckets, of a stationary nozzle arranged at an acute angle adjacent to the side of the wheel and provided with a discharge portion having its bore diverging or increasing in area of cross-section toward its discharge end, substantially as set forth.

"4. The combination with a bucket or turbine wheel, of a stationary nozzle arranged to deliver a jet of expansive fluid against the wheel, and having its cross-sections increasing in area toward its discharge end in a lesser degree than the increase of the volumes of the fluid passing through the respective cross sections, whereby velocity is imparted to the fluid during its expansion in the nozzle, substantially as set forth."

The patent is No. 522,066, and dated June 26, 1894.

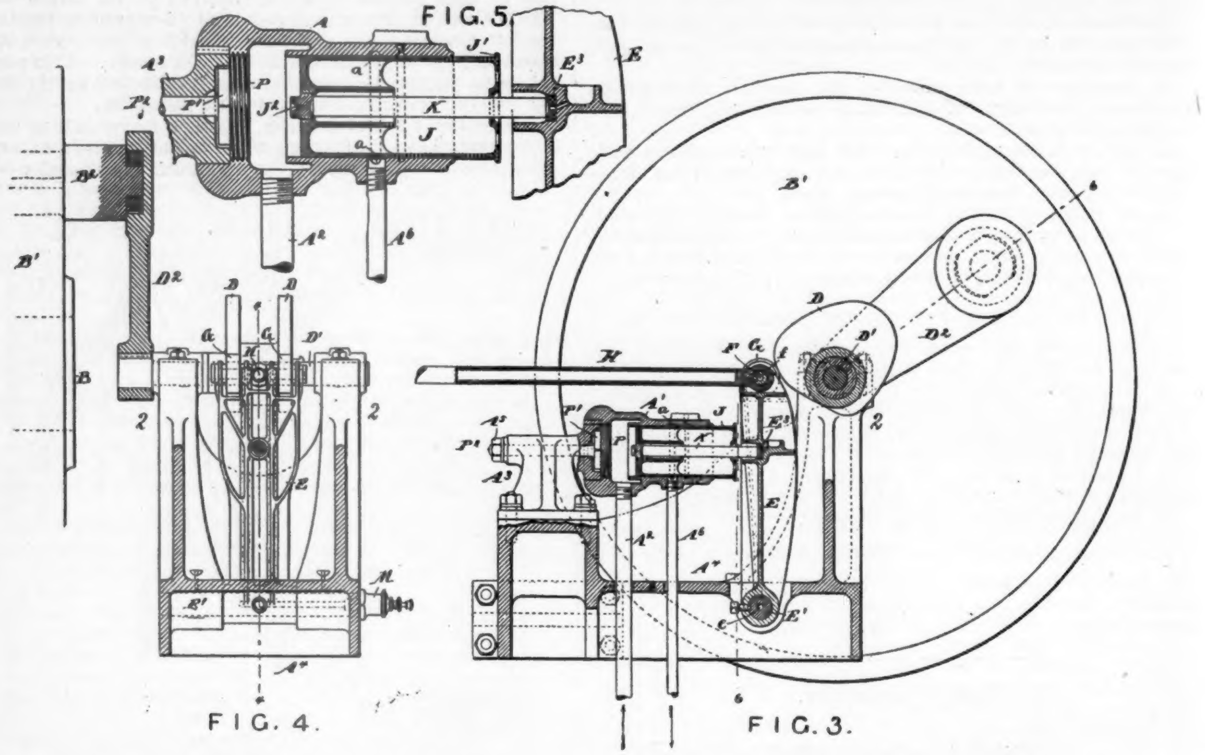


FIG. 5. FIG. 4. FIG. 3.

STEAM-ENGINE.

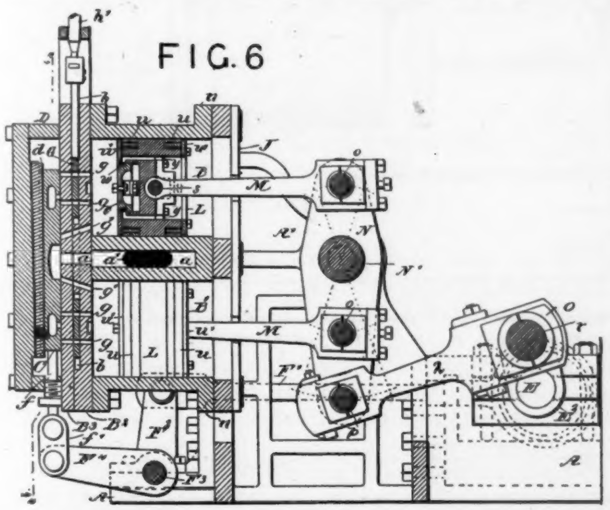
Charles T. Porter, of Montclair, N. J., has patented the arrangement for operating a piston or slide-valves of steam-engines by a cam, which is shown in figs. 3, 4 and 5. Fig. 3 is a front view, looking at the fly-wheel and crank of the engine, with the valve-operating mechanism shown in section.

Fig. 4 is a transverse section drawn on the line 6 6 of fig. 3, and fig. 5 is a view of some of the parts shown in fig. 3, but drawn to a larger scale. Two cams, *D D*, are mounted on a shaft, D^1, which is supported on a stand or bearings, 2, 2, attached to the engine frame or bed-plate. This shaft is driven by a return crank, D^2, which is fastened to the crank-pin B^2. *E* is a lever which is journaled in the fixed bearing E^1. The upper end of this lever has two rollers, *G G*, attached to it which bear against the cams *D D*. A^1 is a cylinder also attached to the engine frame, and provided with an elongated piston, *J*, and a piston-rod, *K*. This rod has rounded ends, which rest in corresponding bearings J^2 in the piston and E^2 in the lever. A^2 is a pipe by which steam, compressed air, or other fluid is conducted to the cylinder A^1, and which forces the piston *J* outward and presses the rod *K* against the lever *E*, and thus keeps the rollers *G G* in contact with the cams *D D*. The rod *H* is connected with the valve, which is thus operated by the action of the cams *D D*. These cams, it is claimed by the inventor, can be made of such a form as will produce a better distribution of steam than is possible with an eccentric. The form which he proposes for these cams is fully described in the patent, which is numbered 517,983, and dated April 10, 1894.

QUICK-SPEED STEAM-ENGINE.

Mr. John P. Devoissaud, of Sherman, Tex., is the inventor of the steam-engine, a longitudinal section of which is represented by fig. 6. It consists of two single-acting cylinders, *B* and B^1, the pistons of which are connected to an oscillating beam, *N*, which in turn is connected to a crank-shaft, *E*, by a connecting-rod, *Q*. Both pistons are operated by a single slide-valve, *C*, which is moved by an eccentric *F*, rod F^1, rock-shaft F^2 F^3 F^4, and valve-stem *f*, in a manner which will be apparent from the engraving without other explanation. *G* is a throttle-valve, but the object in constructing it in that form

FIG. 6



is not apparent. The inventor has evidently aimed to balance one piston by the movement of the other. The patent is numbered 519,943, and dated May 15, 1894.

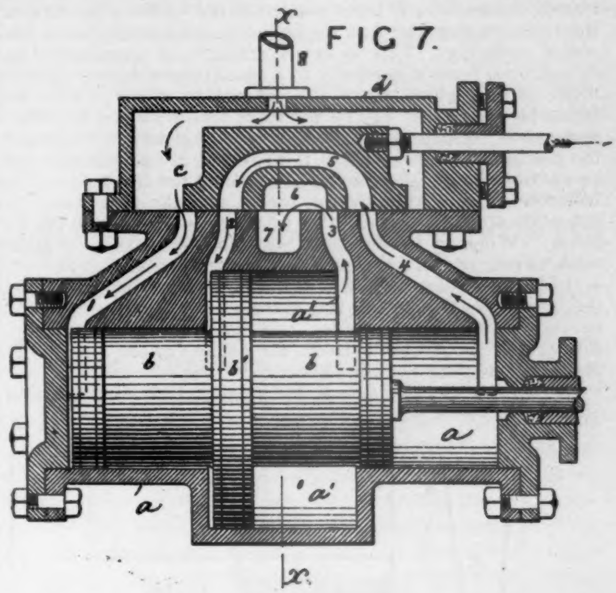
STEAM-ENGINE.

Mr. Benjamin Franklyn Sparr, of Brooklyn, N. Y., has patented the form of compound engine, the cylinder of which is shown by fig. 7, and is described as follows in his specifications:

"The letter *a* represents a steam cylinder provided with an enlarged central chamber, *a'*, and with contracted ends at both sides of said chamber. The piston-head *b* is provided at its center with a fixed collar, *b'*, adapted to reciprocate within chamber *a'*, while the two ends of the piston are of a size to engage the two contracted ends of the cylinder. The cylinder *a* is provided with four ports, 1, 2, 3, 4, of which the ports 1 and 4 enter the extreme ends of the cylinder itself, while the ports 2 and 3 enter opposite ends of the chamber *a'*. The valve *c* is provided with the steam duct 5, adapted to register with the ports 1, 2, 3, and 4, and with a duct, 6, adapted to register with the exhaust 7.

"The operation of the engine will be readily understood. Steam enters the valve chamber *d*, through pipe 8, and passes into port 1, to move the piston toward the right. The valve *c* will move past port 1, to open the same fully. At the same time the steam from port 4 will pass through duct 5 and port 2, against the left-hand face of collar *b'*, to assist the steam entering through port 1. The steam from the right-hand side of collar *b'* goes to the exhaust by passages 3, 6, and 7. When the piston has reached its extreme position, the operation of the parts is reversed. That is to say, the live steam enters port 4 from the valve chamber, and the steam from

FIG 7.



the left-hand end of the piston passes through port 1, duct 5, and port 3 to the right-hand side of collar *b'*. The steam from the left-hand side of such collar is exhausted through passages 2, 6, and 7."

It is not clear from the engraving how the central piston or "collar *b'*," as the inventor calls it, could be put into the large cylinder or central chamber *a'*. It would seem to be essential to make the small cylinders, or one of them, separate from the large one and then bolt them together. The plan appears to have considerable merit, and is especially adapted to compound locomotives.

The number of the patent is 520,456, and its date May 29, 1894.

CAR BUFFER.

Mr. William F. Richards, of Buffalo, N. Y., is the inventor of the arrangement shown by fig. 8, and has assigned the patent to the Gould Coupler Company.

He has described his invention as follows in his specifications:

"This invention relates to the buffers or yielding platform extensions which are applied to the ends of railway cars, and more especially to buffers of this kind which are capable of an oscillating motion, so as to accommodate themselves to the position of the cars in rounding curves. These buffers are provided with extension springs for holding them in contact with the buffer of an opposing car, so as to form a continuous platform between the cars. When the cars are coupled, the extension springs of the buffers are compressed, and in order to permit the cars to be easily coupled and uncoupled, the springs must be comparatively light.

"My invention has for its object to provide the buffer with simple and inexpensive means whereby an increased or supplemental pressure may be applied thereto, after the cars have been coupled, so as to hold the buffers of opposing cars in firmer contact with each other and thereby check or avoid the disagreeable rolling or swaying motion of the cars, without, however, interfering with the easy coupling or uncoupling of the same.

"Fig. 8 is a sectional top plan view of the platform and adjacent portion of a railway car containing my improvement, the flooring being omitted to expose the parts underneath the same.

"*A* represents the longitudinal timbers of the stationary car platform, *B* the cross timber connecting the outer ends of the longitudinal timbers, and *C* the end sill of the car body.

"*D* is the buffer or yielding platform extension which preferably consists of a transverse vertical buffer plate having at its upper end a horizontal threshold plate, *d*, extending inwardly over the end timber *B* and overlapped by a foot-plate, *d'*, secured to said timber.

"*E* is the main buffer stem which carries the buffer and which is guided with its outer portion in a central opening formed in the end timber of the platform, and with its contracted inner portion in an opening, *e*, formed in a block, *E'*, secured between the longitudinal central timbers of the platform.

"*F* is the light extension spring of the buffer, which surrounds the contracted inner portion of the buffer stem between the collar or shoulder *f* of the latter, and the bottom of a horizontal socket, *g*. This socket is arranged in a horizontal eye or collar, *h*, formed centrally in a transverse follower or abutment bar, *H*, which latter is arranged to move toward and from the end timber of the platform and is guided in slots or recesses *h'* formed lengthwise in the longitudinal timbers of the platform. The socket *g* is provided at its front end with an annular flange, *g'*, which bears against the front side of the follower *H*, and whereby the socket and the rear end of the extension spring are compelled to move forward with the follower. When in its rearmost position the socket *g* is seated with its rear end in a recess, *i*, formed in the block *E'*.

"*I* is the usual main or heavy buffer spring which surrounds the light extension spring and sustains any heavy shocks that overpower the latter. When this heavy spring comes into action, it is compressed between the collar *f* of the main buffer stem and the flange of the socket *g*.

"*J J* represent the side stems or stay rods of the buffer, which are pivoted at their front ends to the buffer on opposite sides of its pivot and which carry the usual righting springs *K*. These side stems are guided with their front portions in openings formed in the end timber *B*. Their rear portions may be guided in openings formed directly in the end portions of the follower *H*, but they preferably slide in movable tubes *k*, as described and shown in Letters Patent of the United States, No. 495,061, granted to me April 11, 1893, by which construction the side springs serve to hold the buffer from rattling when the cars are uncoupled as well as to right the same. Any other suitable or well-known spring mechanism for projecting the buffer may, however, be employed, if desired.

"*L L'* represent a pair of pressure cylinders arranged in rear of the follower *H*, on opposite sides of the platform center, and each containing a piston, *l*. Each of these pistons has a rod, *l'*, which passes through an opening formed in the front head of the cylinder and is attached at its outer end to the follower, preferably by a vertical bolt, as shown in fig. 1. The pressure cylinders may be supplied with any suitable fluid under pressure for actuating their pistons, but they are preferably supplied with compressed air from an auxiliary reservoir, *M*, connected by a pipe, *m*, with the reservoir which supplies compressed air for applying the brakes of the car. A reducing valve, *m'*, of an ordinary construction is preferably arranged in the pipe *m*. m^2 is the main supply pipe connected with the auxiliary reservoir, and m^3 m^4 are branch pipes leading from said pipe to the rear ends of the pressure cylinders.

"*N* is a three-way cock or valve, of any suitable construction, arranged in the main supply pipe m^2, and having its ports so arranged that upon turning the valve in one direction the pressure cylinders are placed in communication with the reservoir, while upon turning it in the opposite direction, the supply of air to the cylinders is shut off and the air in the same is allowed to escape, to permit the pistons to return to the rear ends of the cylinders.

"In the normal position of the parts, before the cars are coupled, the follower is in its rearmost position and bears against the rear ends of the recesses in which it is arranged, and the pistons of the pressure cylinders are at the rear extremity of their stroke, as indicated in fig. 8. In this position of the parts, the follower *H* serves merely as a stationary rear abutment for the various springs of the buffer, and upon coupling the cars, the buffer is pressed inward in the ordinary manner. After the cars have been coupled, compressed air is admitted to the pressure cylinders by properly turning the three-way valve in the main pipe m^2. The compressed air entering the cylinders behind their pistons forces the latter to the front end of the cylinders, thereby moving the follower forward with the same, and further compressing the several springs between their abutments. The supplemental pressure thus applied to the springs is exerted upon the buffer, causing the same to be pressed with correspondingly increased force against the buffer of the opposing car, thereby restraining the movements of the buffers upon each other and avoiding the unpleasant rocking or swaying motion of the cars which is permitted by an ordinary spring buffer.

"When it is desired to uncouple the cars, the three-way valve of the main air-pipe is turned in the proper direction to shut off the further supply of air to the pressure cylinders and permit the air to escape therefrom. The pressure being now removed from the rear side of the follower, the compressed springs expand to their former light tension and return the follower to its normal position, permitting the cars to be uncoupled without difficulty."

FIG. 8.